SPECIAL REPORT 94-30

CRREL

Layer Coefficients for NHDOT Pavement Materials

Vincent C. Janoo

September 1994

Abstract

In 1992, the New Hampshire Department of Transportation (NHDOT) experimented with the use of reclaimed asphalt concrete as a base course material, identified by NHDOT as reclaimed stabilized base (RSB). The RSB and a control test section were placed on Interstate 93 between exits 18 and 19. The RSB test section was designed to the same structural number (SN) as the control. To evaluate the structural capacity of these test sections, the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) conducted deflection tests using a Dynatest 8000 falling weight deflectometer (FWD). Preliminary analysis of the results by NHDOT personnel showed higher deflections in the reclaimed asphalt concrete test sections. The explanation was that the layer coefficient used for the RSB layer in the design was probably incorrect. A total of 10 test sections constituting the base course materials used by NHDOT were built near Bow, New Hampshire. CRREL evaluated and estimated the layer coefficients of the base course materials. The test program was developed to characterize the material in more than one way. Tests were conducted with the heavy weight deflectometer (HWD), dynamic cone penetrometer (DCP) and the Clegg hammer. In-situ California bearing ratio (CBR) tests were also conducted. The deflections from the HWD were used with the WESDEF back-calculation program to determine the layer moduli. The moduli were than used with the AASHTO Design Guide to calculate the layer coefficients. The layer coefficients were also determined with the method proposed by Rohde. The CBR values from the Clegg hammer, in-situ CBR and DCP tests were also used in the relationships in the HDM model to determine the layer coefficients.

For conversion of SI metric units to U.S./British customary units of measurement consult ASTM Standard E380-89a, *Standard Practice for Use of the International System of Units,* published by the American Society for Testing and Materials, 1916 Race St., Philadelphia, Pa. 19103.

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Special Report 94-30

US Army Corps of Engineers
Cold Regions Research & Engineering Laboratory

Layer Coefficients for NHDOT Pavement Materials

Vincent C. Janoo

September 1994

Prepared for
NEW HAMPSHIRE DEPARTMENT OF TRANSPORTATION
and
U.S. DEPARTMENT OF TRANSPORTATION, FEDERAL HIGHWAY ADMINISTRATION

PREFACE

This report was prepared by Dr. Vincent C. Janoo, Research Civil Engineer, Civil and Geotechnical Engineering Research Branch, Experimental Engineering Division, U.S. Army Cold Regions Research and Engineering Laboratory. Funding was provided by the New Hampshire Department of Transportation (NHDOT) in cooperation with the U.S. Department of Transportation, Federal Highway Administration.

Technical review of the manuscript of this report was provided by Alan Rawson, Alan Perkins, Glenn Roberts and Paul Mathews (NHDOT) and William Quinn and Robert Eaton (CRREL). Special thanks are given to Kristine Rezendes for managing the data and keeping track of the project; John Bayer, Christopher Berini, Richard Roberts, Brian Waehler and Pamela Chin for conducting the field tests; and also to our guest, Erik Simonsen from the Royal Institute of Technology, Sweden, for assisting in the testing program.

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VINCENT C. JANOO

INTRODUCTION

In 1992 the New Hampshire Department of Transportation (NHDOT) experimented with its use of reclaimed asphalt concrete as a base course material. NHDOT identifies asphalt concrete and crushed gravel base mixed in place as Item 306, reclaimed stabilized base (RSB). Falling weight deflectometer (FWD) tests were conducted on a section where 76 mm of asphalt concrete had been removed from the original pavement structure on Interstate 93 between exits 18 and 19. This is identified as the control section. Later, the remaining asphalt concrete layer was crushed and mixed in place with part of the existing base course. This is identified as an RSB section. It was assumed that the RSB test section had the same structural number (SN) as the control. Prior to placing the final 76 mm on the RSB section, FWD tests were again conducted.

The FWD tests were conducted by the U.S. Army Cold Regions Research and Engineering Laboratory (USACRREL) using a Dynatest 8000 falling weight deflectometer. Preliminary analysis of the results by NHDOT personnel showed higher deflections in the RSB section, suggesting a lower SN than the control. The explanation was that the layer coefficient used for the RSB layer in the design was probably incorrect.

NHDOT uses the *American Association of State Highway and Transportation Officials (AASHTO) Guide for Design of Pavement Structures.* This design procedure uses the SN concept developed from the AASHTO Road tests conducted in the late 1950s and early 1960s. The SN of a pavement structure is an index that describes the structural capacity of the pavement based on the expected traffic, subgrade and drainage conditions. The different pavement layers contribute to the overall bearing capacity, identified by the SN. The contribution is by layer of thickness, which is controlled by the material used in the layers. The stiffness of the layer is characterized by a layer coefficient (a_i). Mathematically, the SN can be related to the thicknesses of the layers by the following equation:

$$\mathrm{SN} = a_1 d_1 + m_1 a_2 d_2 + m_2 a_3 d_3 = \sum_{i=1}^{n} a_i\, d_i$$

where a_i = layer coefficient
d_i = thickness of the layer
m_i = drainage coefficient of the layer.

The layer coefficient is a multiplier for the thickness of the layer(s) required to carry the expected load. The stiffer the supporting layer, the higher the a_i will be. For example, from the AASHTO road tests, the layer coefficient of asphalt is 0.44; for crushed stone base course, it is 0.14; and for sandy gravel subbase, 0.11. Currently NHDOT uses the following layer coefficients as shown in Table 1.

Based on the results from the RSB test section, NHDOT decided to reevaluate the layer coefficients used in their design. A Cooperative Research and Development Agreement (CRDA) was established between CRREL and NHDOT to determine the layer coefficients of the reclaimed stabilized base and reevaluate the layer coefficients of the other commonly used base and subbase materials in the State of New Hampshire.

Test sections of different materials were built by NHDOT near Concord off Interstate 89 in 1993. USACRREL conducted FWD and other tests on these test sections. The aim was to use the deflections to back-calculate the layer modulus (E_i). This E_i is then used with established relationships for determining the layer coefficients in the *1993 AASHTO Guide for Design of Pavement Structures.* This report

Table 1. Layer coefficients used by NHDOT.

Material	*Layer coefficients* (a_i)
Hot bituminous base course	0.34
Hot bituminous binder and wearing course	0.38
Crushed gravel base	0.10
Gravel base	0.07
Crushed stone	0.14
Sand	0.05
Reclaimed stabilized base	0.17

describes the tests conducted and analysis performed to determine the layer coefficients.

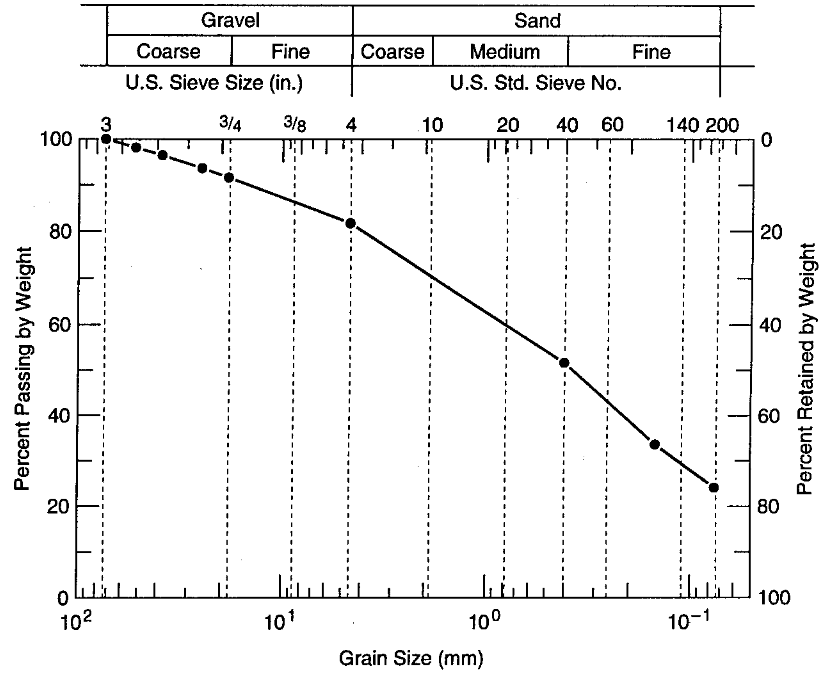


Figure 1. Gradation curve of subgrade soil.

DESCRIPTIONS

Description of test site

NHDOT provided a test area near Bow, New Hampshire. The test area was located in an area used as a maintenance site by the contractors for a paving project on Interstate 89. This site was parallel to the interstate between exits 2 and 3 Southbound, approximately 3.2 km from the Concord town line.

Prior to the construction of the test sections, the subgrade was leveled and compacted to required NHDOT specifications. Since back-calculation methods were planned to determine the base course modulus, it was necessary to know if any bedrock was close to the surface. Data analysis problems have been encountered when rigid layers close to the surface are not taken into account. NHDOT performed a seismic refraction test and made some borings down to a depth of approximately 3.3 m. The results from the auger holes showed no bedrock to 3.3 m. The seismic refraction data showed no bedrock to a depth of 27 m.

Visual observation showed large boulders excavated at the site. It appears that the subgrade in the area was glacially deposited with suspended boulders below grade. Gradation analysis of the subgrade was performed by NHDOT personnel. The results from the gradation analysis are presented in Figure 1.The soil is classified as a silty sand (SM) using the Unified Soil Classification System because of the high amount passing the no. 200 sieve. With respect to AASHTO classification, the subgrade could be classified as an A2-5 soil.

Description of test sections

A total of 10 test sections were built. The test sections were 30.5 m long × 3.7 m wide. The design thickness for all test sections was 200 mm. The location of the test sections is shown in Figure 2. The materials used in the test sections are shown in Table 2. The number in the parenthesis, next to the material, is the required gradation specification number of NHDOT. Detailed specifications of the material can be found in the NHDOT specifications book.

For base course materials, the specifications call for hard durable particles of stone or gravel, resistant to deterioration when subjected to either freeze-thaw or wet-dry cycling. The fines can be either natural or processed sand. For crushed gravel, at least 50% of the material retained on the 25-mm sieve shall have a minimum of one fractured face.

RSB is a blend of pulverized asphalt concrete and crushed base course gravel. Because of the difficulty of meeting the gradation (306), an amendment was made to the gradation. The current requirement is 100% passing the 75-mm sieve. Four RSB test sections were constructed at the test site. According to NHDOT, the minimum 3% asphalt content specified has been difficult to achieve. To evaluate the effect of the asphalt content on the RSB, the percentages chosen for this research were 2%, 3% (two test sections), and 4%. One of the 3% asphalt content RSB test sections was compacted in two 100-mm layers. The reason for the 100-mm lift for the RSB test section was that NHDOT personnel had concerns that in thicker lifts, the bottom layers might have compaction values lower than in the upper layers. They believed that some form of

Table 2. Materials used in test sections.

Gravel (304.2)
Crushed gravel (304.3)
Crushed stone—fine (304.4)
Crushed stone—coarse (304.5)
Reclaimed stabilized base (306)
Asphalt concrete
Pavement millings

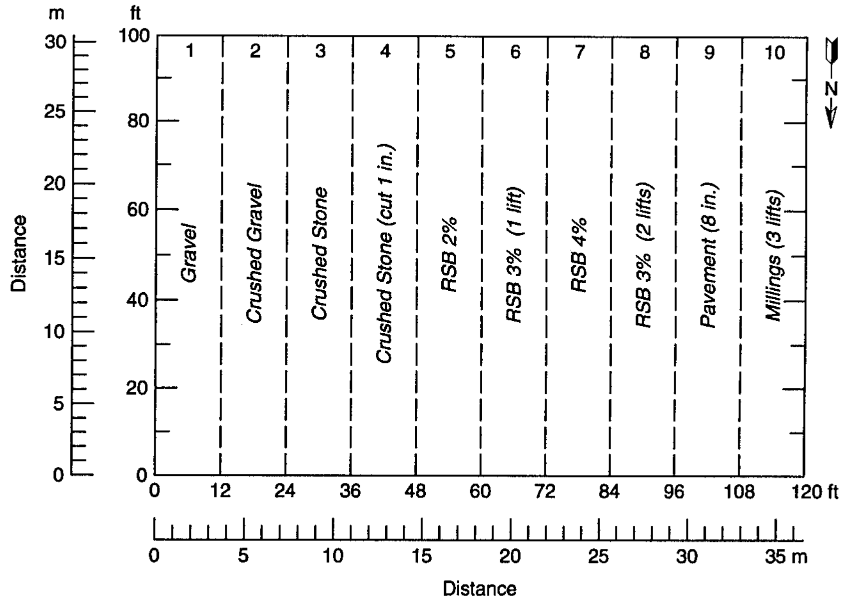


Figure 2. Materials used in test sections.

"bridging" might occur in the lower layers because of the cementatious nature of the material.

The pavement millings were placed in 3 lifts (75 mm, 75 mm, and 50 mm). The asphalt concrete pavement was placed in two 63-mm lifts of 31.5-mm base course, one 44-mm lift of 19-mm binder course, and one 25-mm lift of 12.5-mm wearing course.

Bag samples of the different materials were obtained during construction. CRREL personnel conducted gradation analysis of the test materials. The results of the gradation analysis are presented in Appendix A. Included in the figures are photographs of the test materials.

TEST PROGRAM

The test program was developed to characterize the material in more than one way. Tests were conducted with the heavy weight deflectometer (HWD), dynamic cone penetrometer (DCP) and the Clegg hammer. The HWD is basically an FWD that applies a greater load: the maximum load applied by an FWD is 120 kN and by an HWD is more than 240 kN. In-situ California bearing ratio (CBR) tests were also conducted.

As mentioned above, the deflections from the FWD can be used with back-calculation techniques to determine the layer coefficients. Also, Rohde (1994) and Noureldin (1992) have developed methods for determining the SN of a pavement structure using the deflection data only. Back-calculation using layered elastic theory of layer moduli is not required by these methods. Rohde developed regression equations, based on a statistical study, between one or two of the measured deflections with the SN of the pavement. Chastain et al. (1964) developed relationships between CBR and layer coefficients from their studies of the AASHTO Road Tests. CBR results can also be inferred from DCP tests. Webster (1992) and Kleyn and Savage (1982) developed relationships between the penetration rate of the DCP and CBR. The CBR values from the Clegg hammer, in-situ CBR and DCP tests will be used in the relationships in the HDM model (Watanatada et al. 1987) to determine the layer coefficients.

Prior to construction of the test sections (14–16 August 1993), the subgrade was tested with the HWD, Clegg hammer, DCP and in-situ CBR test. The FWD (or HWD) is now commonly used by many state DOTs to evaluate their pavement structure (Fig. 3). Basically, a HWD applies a known load on the surface of the pavement or subgrade. The pavement or subgrade deflects and the seven geophones, located at various distances from the center of the load, measure the surface deflection (Fig. 4).

Generally, the deflections are used with layered elastic theory to back-calculate the layer moduli of the pavement structure. Currently, there are many sophisticated back-calculation computer programs, such as the Corps of Engineers' WESDEF and the Strategic Highway Research Program's (SHRP) MODULUS for this purpose. Basically the programs iterate to a solution by varying the layer moduli. The solution is obtained when the error between the calculated and measured deflections are minimized. The program reports the layer moduli. For simple systems, such as a one-layer system (as in our case with the subgrade), the elastic modulus can also be

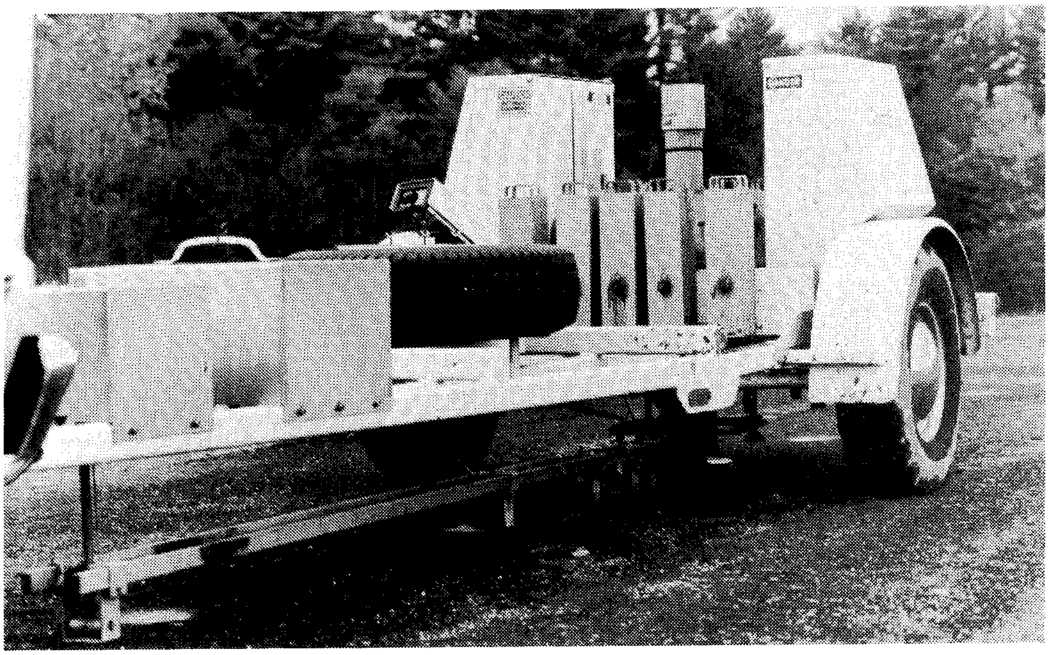


Figure 3. Heavy weight deflectometer (HWD).

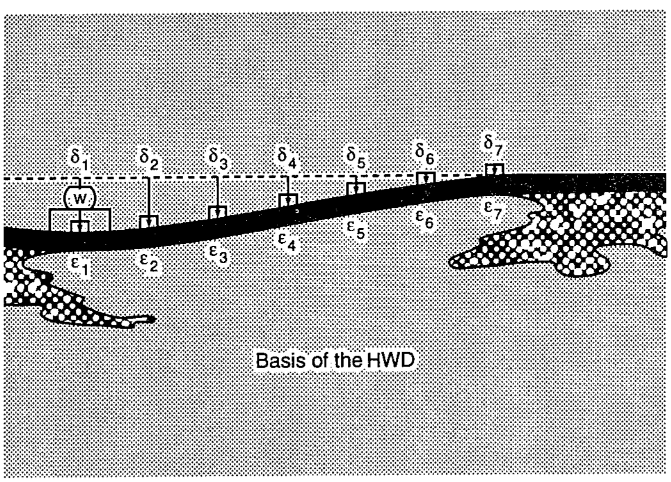


Figure 4. Basis of HWD testing.

back-calculated using the modified Boussinesq equation. With two layer systems we can use the two-layered Burmister model or use WESDEF to back-calculate the layer moduli. We used WESDEF to back-calculate the layer moduli of layers in the test sections. The back-calculated base course layer moduli were then used with relationships presented in the *AASHTO Guide for Design of Pavement Structures* to obtain the layer coefficients (a_i).

The SHRP protocol for pavement evaluation was used in the HWD test program. The tests were conducted at four load levels. The loading sequence used on the subgrade and base course test sections is as follows. Three seating loads are applied at the third load level and then each load level is applied four times to the surface. On the subgrade, the load levels used were approximately, 20, 33, 44 and 53 kN. Normally, the 300-mm loading plate is used. However, to minimize the stress on the subgrade surface, a larger plate (diam. = 450 mm) was used. The seven geophones for the subgrade testing were located 0, 305, 457, 610, 914, 1219 and 1524 mm from the center of the load. On the base test sections, load levels around 27, 38, 44 and 53 kN were used. The seven geophones for the base course testing were located 0, 200, 305, 457, 610, 914, and 1524 mm from the center of the load.

HWD measurements were conducted starting and ending 3.0 m from the ends of the test sections. In between, tests were conducted at 1.5-m intervals, for a total of 17 points (Fig. 5). The deflections were normalized to the standard 40 kN. The normalized results are presented in Appendix B.

Clegg hammer and DCP tests were conducted on the subgrade and on the completed test sections. The Clegg hammer is essentially a modified AASHTO compaction hammer fitted with a piezoelectric accelerometer (Fig. 6). It is used in Canada, Europe and Australia for compaction control of subgrade, subbase and base courses. A 4.5-kg hammer is raised to a height of 457 mm inside a guide tube and dropped. A hand-held meter measures the peak deceleration as the hammer hits the surface.

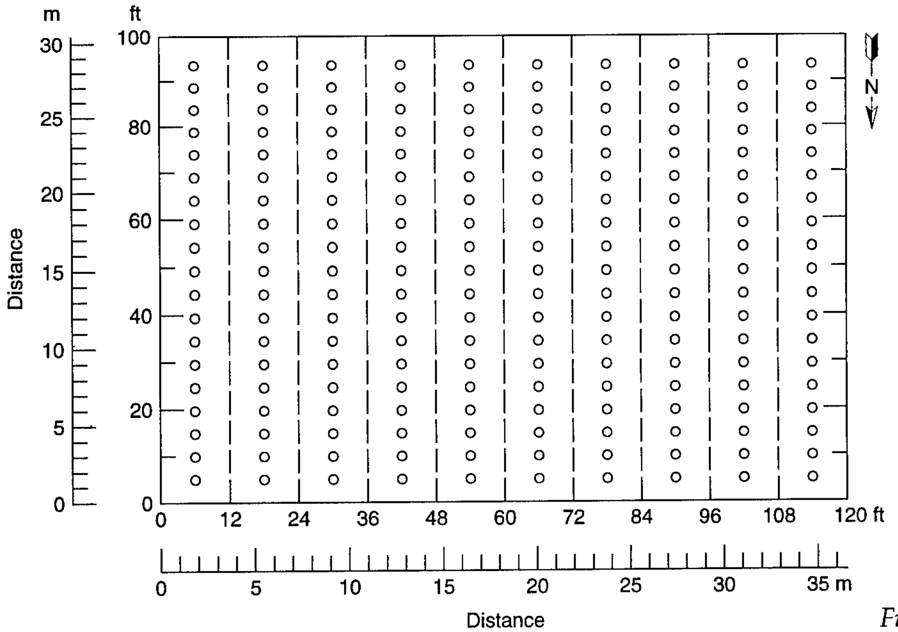


Figure 5. Location of FWD points.

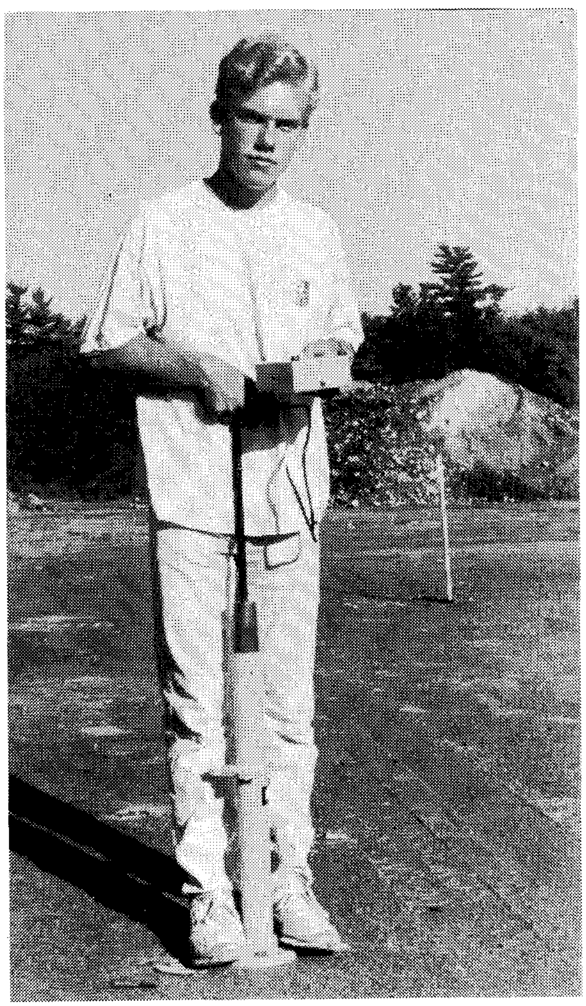


Figure 6. Clegg hammer.

The deceleration is presented as the Clegg impact value (CIV). A relationship between the CIV and CBR has been established:

$$CBR(\%) = 0.07\ (CIV^2)$$

A similar relationship was found between the elastic modulus (E, in kPa) and CIV:

$$E = 70\ (CIV^2)$$

The DCP has also been used to characterize the bearing capacity of the supporting layers of a pavement structure. The DCP used in this test program is shown in Figure 7. The DCP consists of a 4.5-kg hammer. The hammer is raised to a height of 584 mm and dropped on the anvil. The force on the anvil drives the cone into the soil. Penetration measurements were made to a depth of approximately 305 mm. The number of blows required to drive the cone to a depth of 25 mm is noted.

The DCP Index, which is the amount of penetration per blow, is calculated by dividing the depth of penetration by the number of blows. Relationships between the DCP index and CBR have been developed by the Corps of Engineers (Webster et al. 1992).

To minimize the effect of site variability, the locations of the DCP and Clegg hammer tests were very close to the FWD test locations. In-situ CBR tests were conducted at 6, 15, and 24 m along the centerline from the beginning of the test section (Fig. 8). Surface elevations on top of the subgrade were taken at the HWD test points. After the test sections

Figure 7. Dynamic Cone Penetrometer (DCP).

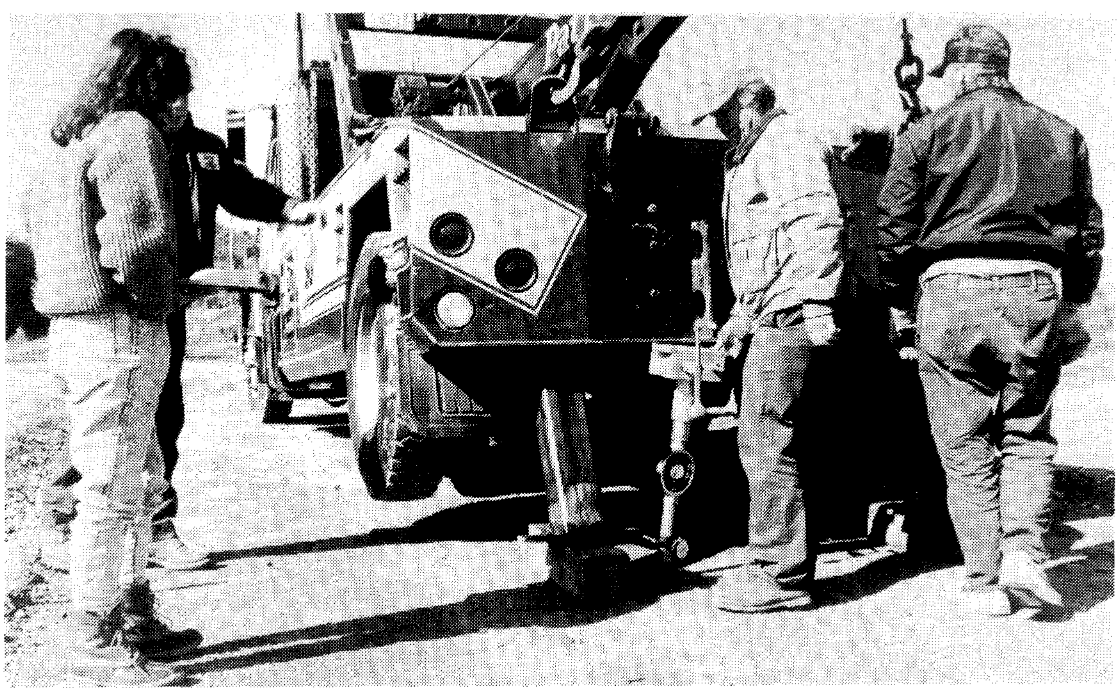


Figure 8. In situ California bearing ratio test.

were built, the HWD points were transferred to the surface of the test sections. The HWD tests were repeated, in the same fashion as done with the subgrade. Similarly, in-situ CBR tests and surface elevations were done on top of the test sections. At the time HWD measurements were made, NHDOT personnel assisted in conducting near-surface density and moisture measurements of the subgrade.

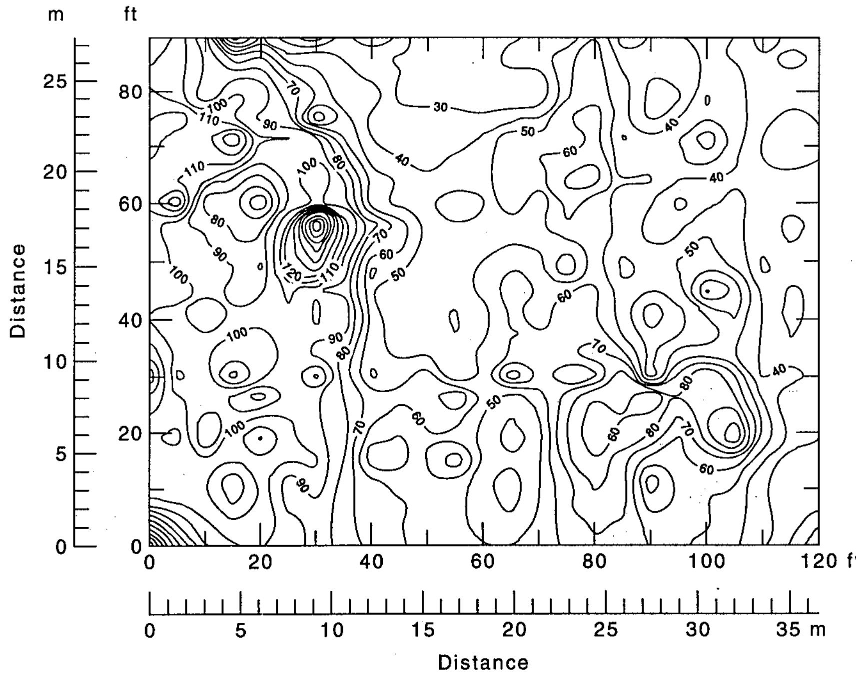


Figure 9. Clegg CBR profile of subgrade.

RESULTS/ANALYSIS OF SUBGRADE TESTING

The load deflection data were normalized to 40 kN, representing half an 80-kN axle load. Since no bedrock was indicated to a depth of 60 ft, the subgrade was idealized as a half space. The vertical deflection equations modified by Ahlvin and Ulery (Yoder and Witzcak 1975) were used to determine the subgrade modulus.

The vertical deflection (Δz) is given by

$$\Delta z = \frac{p(1+\mu)}{E}\left[\frac{z}{d}A + \left[(1-\mu)H\right]\right].$$

If Poisson's ratio (μ) = 0.5 and surface deflections are measured ($z = 0$), then

$$\Delta z = \frac{1.5pa}{E}[0.5H].$$

If we use the deflection under the center plate, then $H = 2.0$ and

$$\Delta z = \frac{1.5pa}{E}$$

or

$$E = \frac{1.5pa}{\Delta z}$$

where p = applied stress (kPa)
a = plate radius (m)
Δz = center surface deflection (m)
E = elastic modulus (kPa).
A,H = Ahlvin and Ulery functions

For a normalized load of $F = 40$ kN and a plate radius of 225 mm then

$$p = \frac{F}{A} = \frac{F}{\pi a^2} = \frac{40}{\pi(0.225^2)} = 252 \text{ (kPa)}$$

and

$$E = \frac{1.5 \times 252 \times 0.225}{\Delta z} = \frac{85}{\Delta z} \text{ (kPa)}$$

The back-calculated subgrade modulus is presented in Appendix C. A comparison is made with the subgrade modulus calculated from the Clegg hammer data. It should be noted that the modulus from the Clegg hammer is from near the surface, whereas the modulus from the FWD is an average of a larger volume of soil. The data show that the modulus from the Clegg hammer in most cases is close to that obtained from the FWD. The modulus also shows that the area close to the interstate, in the area of the test sections 1 and 2, is much stiffer than the other areas. This is further substantiated by the CBR data from the Clegg hammer (Fig. 9) and the near-surface density measurements (Fig. 10). The near-surface gravimetric moisture content at the site ranges between 5 to 10% (Fig. 11).. The wetter areas were close to the area where the test sections 9 and 10 were to be built. It was also observed that when it rained, there was no standing water in the area indicating a soil of high permeability.

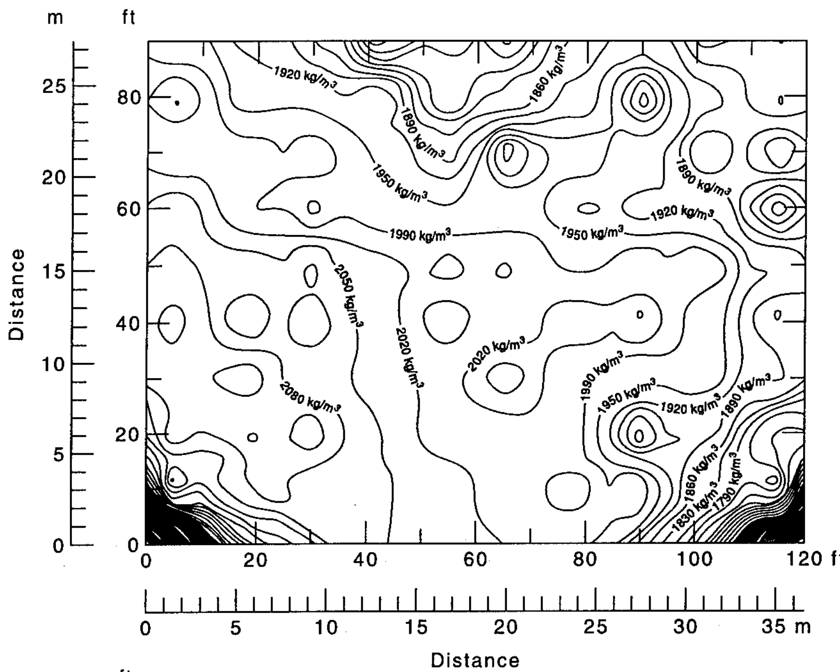


Figure 10. Density profile of subgrade.

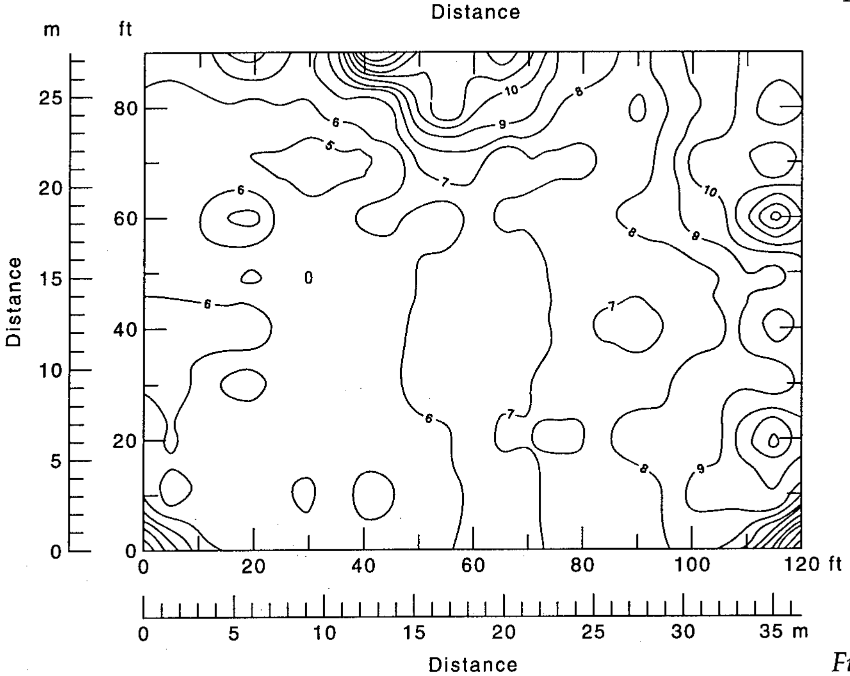


Figure 11. Moisture profile of subgrade.

BASE COURSE TESTING

The base course layers were constructed in mid-September. During the construction, CRREL personnel installed thermocouples on top of the subgrade. These installations were made so that temperature measurements could be made in future studies to determine the seasonal effects on the stiffness of the different base courses. Bag samples of the materials were also collected at that time. CRREL returned to the test area to conduct FWD tests in early October 1993.

Besides the FWD tests, Clegg hammer, DCP, level surveys, and in-situ CBR were conducted. The level surveys were used with those from the subgrade to get the thickness of the test sections. The thicknesses based on our level surveys across the test sections are given in Table 3. These thicknesses and linear elastic theory were used in the Corps of Engineers WESDEF program to back-calculate the layer moduli. These thicknesses were also used in Rohde's method for determining the SN of the various base course layers.

Table 3. Base course layer thicknesses.

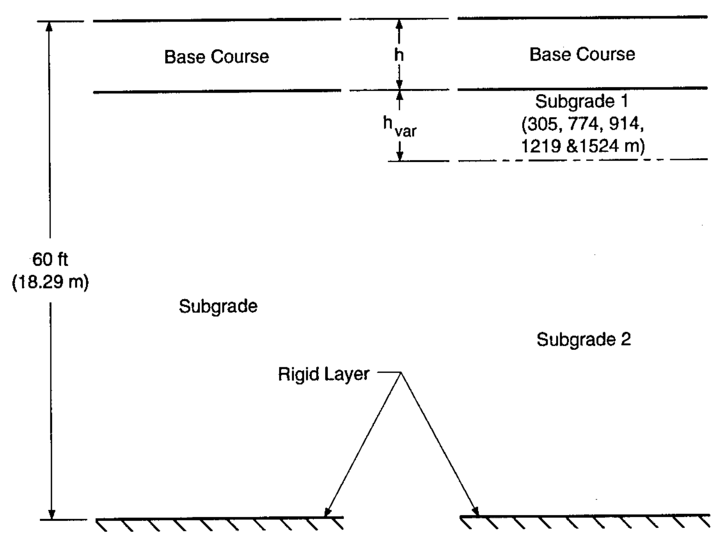
Location ↓	*Thickness of base course (mm)*									
Test section→	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
+10	180	216	216	234	231	224	213	216	172	213
+15	193	231	244	241	234	231	224	203	178	203
+20	172	231	254	246	239	229	213	201	183	208
+25	185	229	249	246	234	216	211	211	185	208
+30	208	239	262	249	224	213	216	216	183	203
+35	226	241	264	257	226	203	224	218	185	201
+40	231	244	259	241	218	196	226	234	185	201
+45	224	241	257	239	229	193	229	226	188	196
+50	224	246	239	241	234	198	224	226	193	203
+55	234	249	241	226	226	201	226	226	203	208
+60	226	259	229	239	234	201	224	211	211	211
+65	231	262	218	224	239	193	218	203	216	211
+70	226	249	216	224	246	213	216	201	231	218
+75	218	249	208	224	246	218	213	196	229	216
+80	224	249	213	218	254	224	211	185	226	231
+85	229	239	211	211	246	218	201	168	229	239
+90	224	229	224	211	229	211	198	152	231	244

DETERMINATION OF LAYER COEFFICIENTS (a_i)

Back-calculation of layer moduli

Initially, the pavement structure was modeled as a two-layer system (Fig. 12a). From past experience with WESDEF, it was found that a rigid layer placed 6 m below the surface produced a better fit between the calculated and the measured deflection basin. Based on the seismic study conducted by NHDOT personnel, no bedrock (rigid layer) was found to a depth of 18 m. In our analysis, we placed a rigid layer separately at 6 and 18 m. The solution did not show much difference. For the two-layer system, it was found that the error between the calculated and measured deflections were extremely large. The pavement structure was remodeled as a three layer system (Fig. 12b). The subgrade was subdivided into two layers. The division was made at 305, 774, 914, 1219 and 1524 mm below the base course layer. The back-calculated base course modulus with the lowest error between the calculated and the measured deflection basin was used in the calculation a_i. The error was reduced significantly when the pavement structure was modeled as a three- instead of a two-layer system.

Prior to conducting the back-calculation of the base course modulus, we used the deflection basin area to locate points where the basin area is within one standard deviation from the mean (Fig. 13–22). The basin area was used to locate areas of similar performance. The mean modulus of the different base courses is presented in Table 4. Note in Table 4, the AC modulus is not presented. This was because the modulus was higher than 3500 MPa. The AASHTO Design Guide relationship between AC modulus and a_i only goes up to 3500 MPa. The higher values result from the pavement being tested when it was cold.



a. Two layer. *(b). Three layer.*

Figure 12. Representation of test sections in WESDEF.

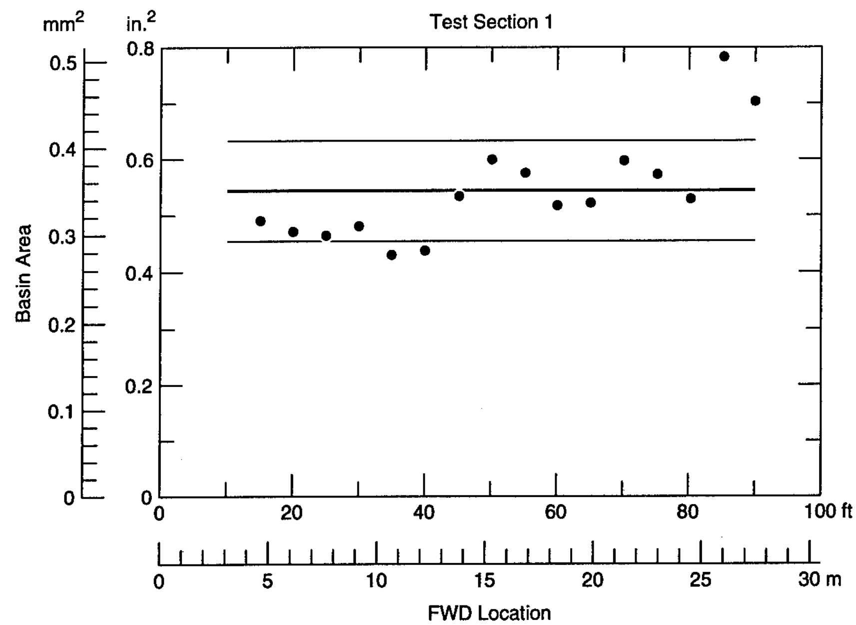


Figure 13. Deflection basin area for gravel.

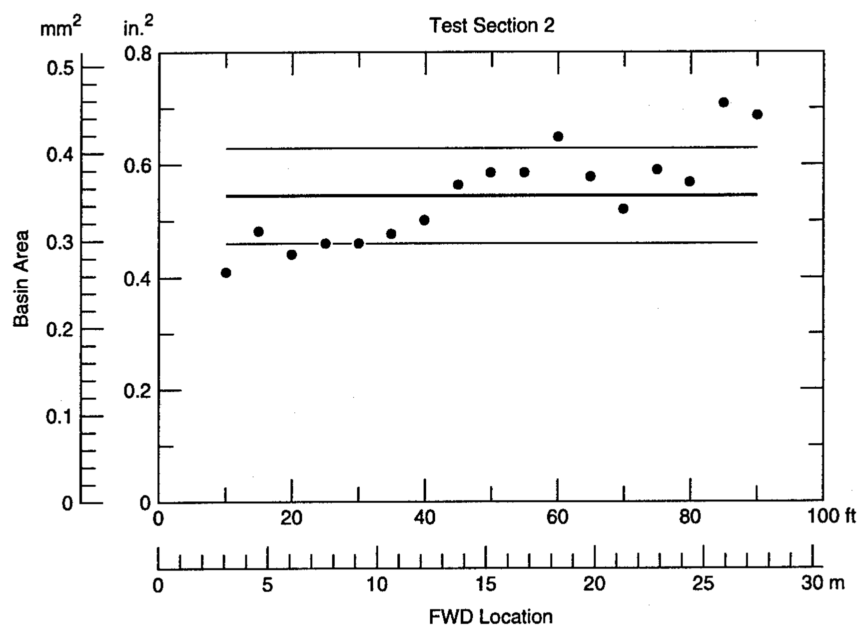


Figure 14. Deflection basin area for crushed gravel.

Table 4. Mean modulus and layer coefficient of base course materials.

Material	E_i *(MPa)*	a_i
Gravel	211	0.12
Crushed stone (fine)	168	0.16
Crushed stone (coarse)	231	0.19
Reclaimed stabilized base (2%)	267	0.17
Reclaimed stabilized base (3%)	262	0.16
Reclaimed stabilized base (4%)	331	0.19
Reclaimed stabilized base (3%—2 lifts)	256	0.16
Asphalt concrete	—	—
Pavement milling	334	0.17

For the gravel, crushed gravel, RSB and pavement millings, the following equation from the *1993 AASHTO Design Guide* was used:

$$a_2 = 0.249 (\log_{10} E) - 0.977.$$

For the crushed stone, the following equation from the *1993 AASHTO Design Guide* was used:

$$a_3 = 0.227 (\log_{10} E) - 0.839 .$$

The following a_i values were calculated from the back-calculated base course modulus. These results are also presented in Table 4.

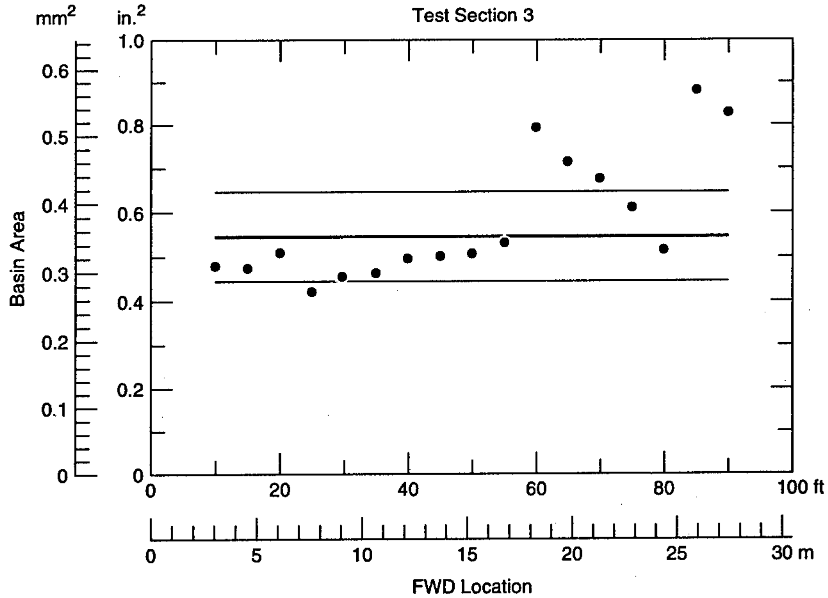


Figure 15. Deflection basin area for fine crushed stone.

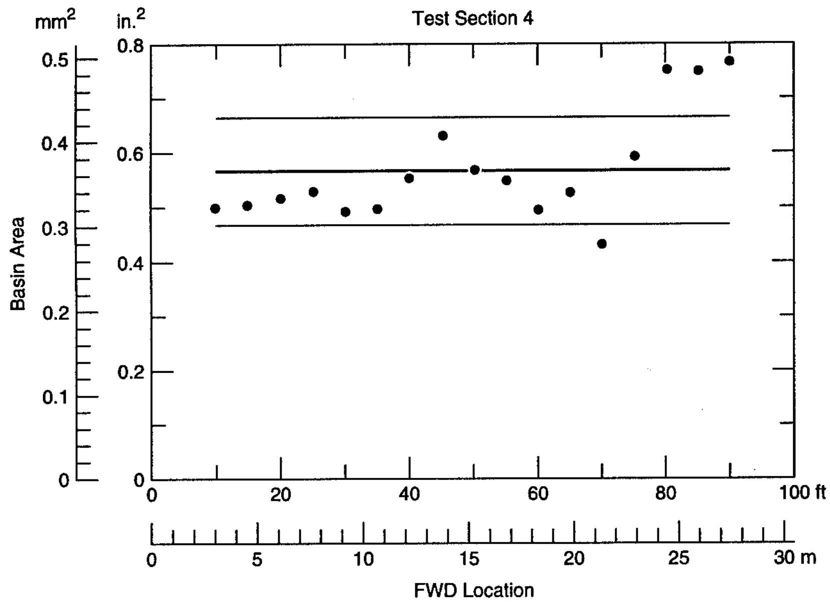


Figure 16. Deflection basin area for coarse crushed stone.

Determination of layer coefficients using FWD data

Rohde (1994) developed a method for determining the SN of a pavement structure using the FWD measurements. The SN equation used is the one modified by TRL in 1975 and used in the World Bank Highway Design and Maintenance pavement performance model (HDM-111 model). The modified structural number (SNC) is defined as

$$\mathrm{SNC} = 0.0394 \sum_{i=1}^{n} a_{i} h_{i} + \mathrm{SNSG}$$

where SNSG is that portion of the structural number contributed by the subgrade. The following relationship for SNSG in terms of CBR has been used:

$$\mathrm{SNSG} = 3.51 \log_{10} \mathrm{CBR} - 0.85 (\log_{10} \mathrm{CBR})^2 - 1.43$$

where CBR = the in-situ California bearing ratio of the subgrade (%).

Based on Irwin's (1983), "two-thirds rule" of stress distribution under a pavement structure,

Rohde assumed that the deflection ($D_{1.5}h$) measured at a distance on the surface equal to 1.5 times the structural section thickness (h) is due to the subgrade only. He then developed the Structural Index of the Pavement (SIP). SIP is associated with the deflection above the subgrade only:

$$\text{SIP} = D_0 - D_{1.5h}.$$

The hypothesis is that the SIP should be strongly correlated with the stiffness of the pavement structure and thus to SN. Based on regression analysis, Rohde developed a relationship between SN and SIP:

$$\text{SIP} = k_1\, \text{SIP}^{k2}\, h^{k3}.$$

The following values, 0.1165, –0.3248 and 0.8241 were used for k_1, k_2 and k_3 for all the base courses with the exception of the asphalt concrete layer. For the AC layer, 0.4728, –0.4810 and 0.7581 were used as recommended by Rohde, respectively. For a two-layer system, the layer coefficient was calculated using

$$a_i = \frac{\text{SNC} - \text{SNSG}}{0.0394 * h}.$$

Rohde (1994) used the deflection data to determine the subgrade modulus (E_{sg}). He developed

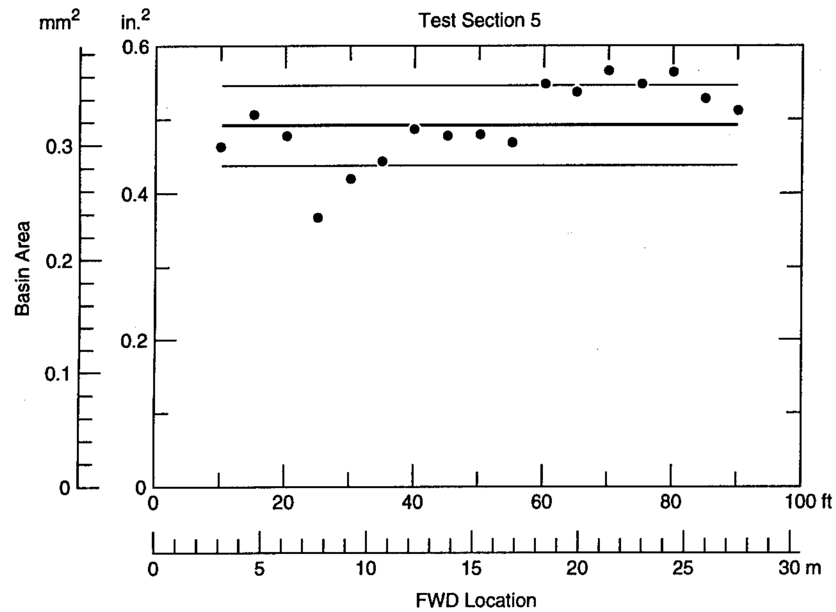


Figure 17. Deflection basin area for 2% RSB.

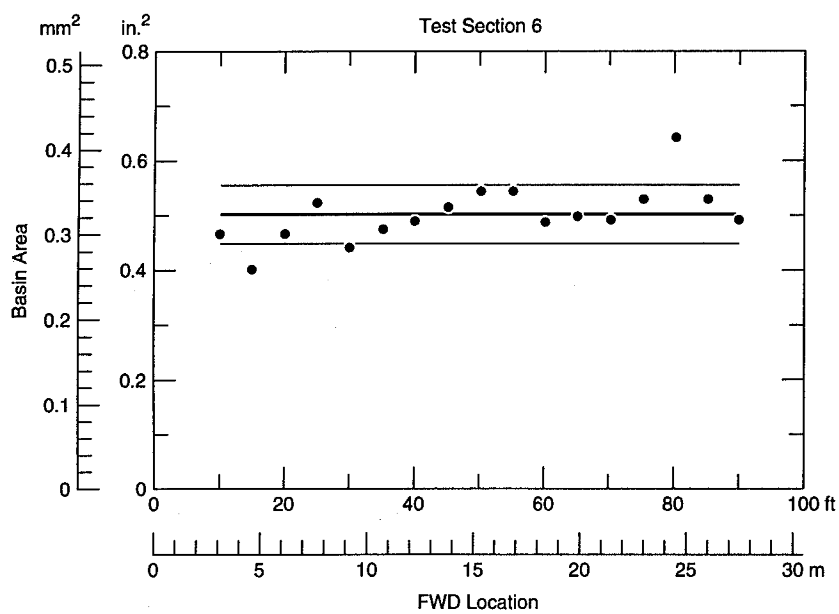


Figure 18. Deflection basin area for 3% RSB.

another index called the structural index of subgrade (SIS):

$$\mathrm{SIS} = D_{1.5h} - D_s \ .$$

where D_s is the deflection measured at a distance of 30 inches from the center plate. The subgrade modulus is

$$E_{sg} = 10^{k4}\,\mathrm{SIS}^{ks}\,h^{k6} \ .$$

The following recommended values of 23138, –1,236 and –1.903 (Rohde 1994) were used for k_4, k_5, and k_6. The CBR (%) of the subgrade was back-calculated from

$$E_{sg} = [1500 \times \mathrm{CBR}^{0.73}]/6.9, \text{ (kPa)}.$$

The mean a_i are presented in Table 5. The results are compared with that obtained from back-calculation. The subgrade moduli obtained from the modified Boussinesq equation were also used in place of E_{sg} and the layer coefficients back-calculated. There were no significant differences between the two of them.

Determination of layer coefficients using CBR results

Field CBR data were obtained from the Clegg hammer and in-situ CBR testing (App. D). Also data from the DCP can be converted to CBR. The DCP data are converted to penetration per blow rate. The Corps of Engineers use the following relationship to convert the DCP rate to CBR:

$$\mathrm{CBR}(\%) = \frac{292}{\mathrm{DCP}^{1.12}}$$

where DCP = millimeters/blow.

Table 5. Layer coefficients for base course using Rohde's method.

Material	*Rohde (1994)*	*Back-calculation*
Gravel	0.12	0.10
Crushed gravel	0.13	0.12
Crushed stone (fine)	0.13	0.16
Crushed stone (coarse)	0.14	0.19
Reclaimed stabilized base (2%)	0.14	0.17
Reclaimed stabilized base (3%)	0.14	0.16
Reclaimed stabilized base (4%)	0.15	0.19
Reclaimed stabilized base (3%—2 lifts)	0.14	0.16
Asphalt concrete	0.37	—
Pavement milling	0.15	0.17

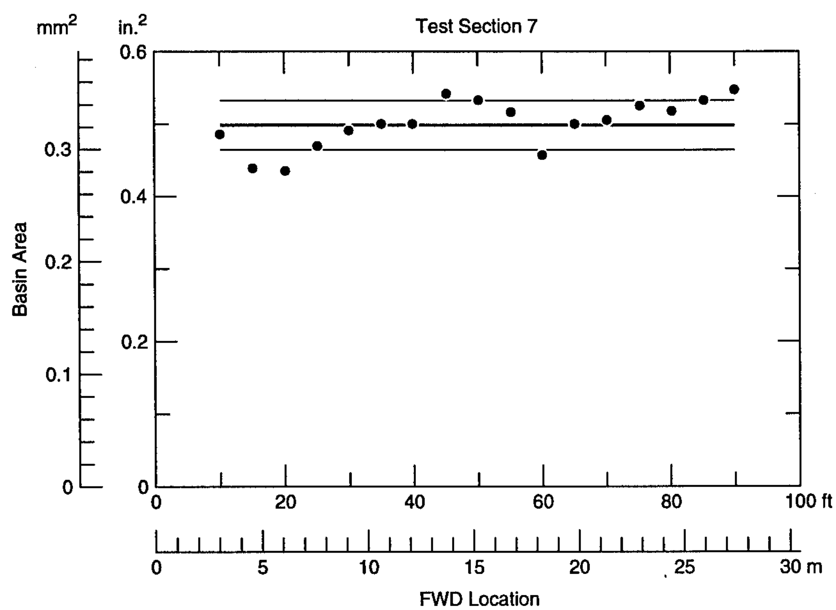


Figure 19. Deflection basin area for 4% RSB.

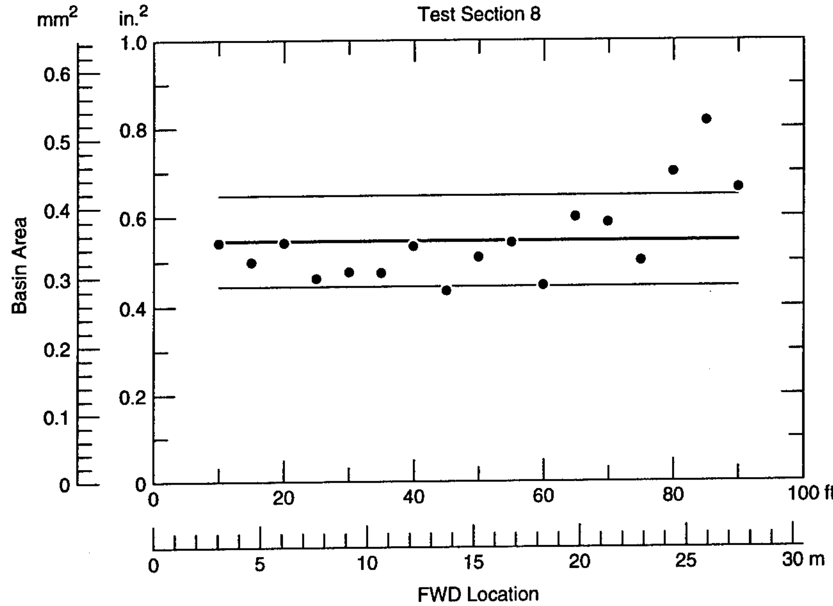


Figure 20. Deflection basin area for 3% RSB—two lifts.

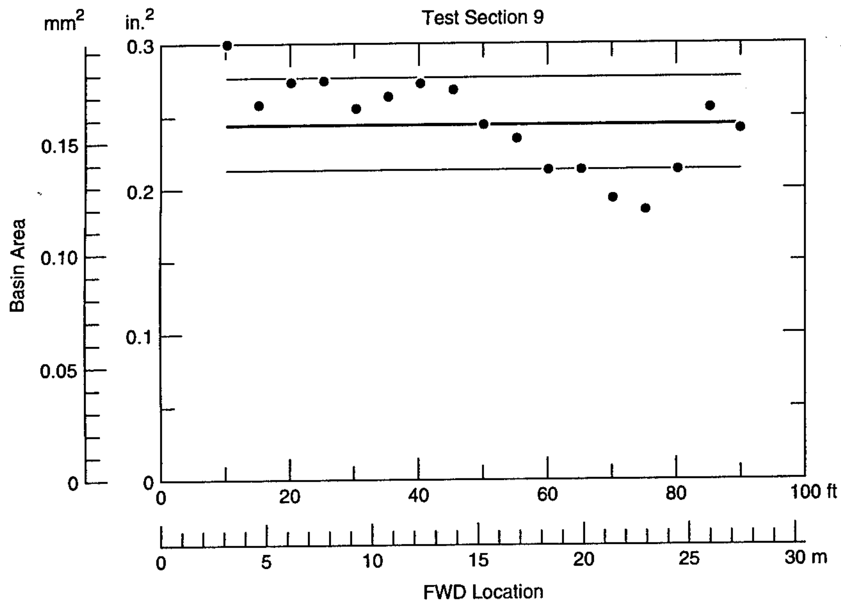


Figure 21. Deflection basin area for asphalt concrete.

Table 6. Back-calculated a_i from in-situ tests.

Material	*Clegg hammer*	*In situ*	*DCP*
Gravel	0.07	0.02	0.04
Crushed gravel	—	0.07	0.07
Crushed stone (fine)	0.10	0.05	—
Crushed stone (coarse)	0.13	0.08	—
Reclaimed stabilized base (2%)	*	0.06	0.11
Reclaimed stabilized base (3%)	0.15	0.10	0.13
Reclaimed stabilized base (4%)	*	0.08	0.13
Reclaimed stabilized base (3%—2 lifts)	0.14	0.09	0.13
Asphalt concrete	—	—	—
Pavement milling	—	0.07	0.14

* unreasonable values.

In the World Bank HDM-111 pavement performance model, there is a relationship between CBR and a_i,

$$a_i = (29.14 \times \text{CBR} - 0.1977\ \text{CBR}^2 + 0.00045\ \text{CBR}^3)\ 10^{-4}\ .$$

The results from the calculations are presented in Table 6.

The in-situ test results in Table 6 are low when compared with either the Clegg hammer or DCP test results. This is probably due to the test method itself. The test involves measuring the

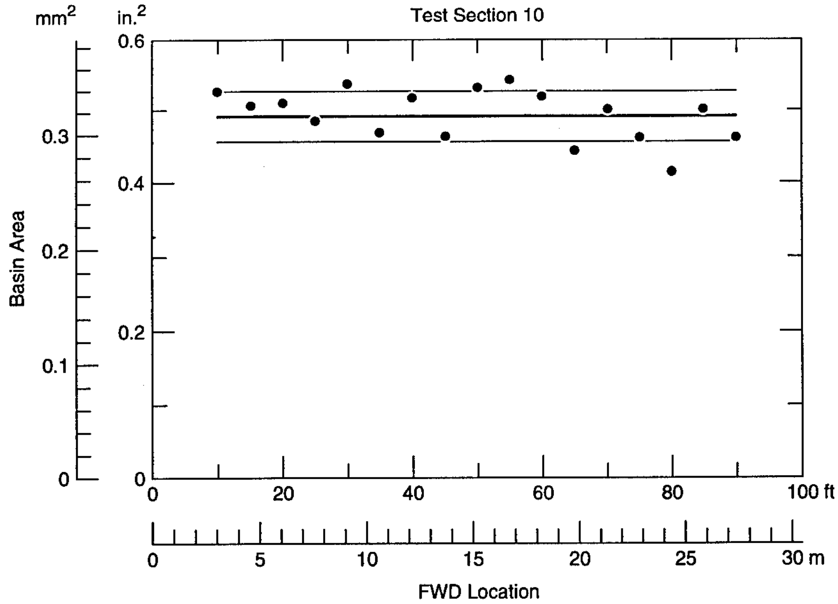


Figure 22. Deflection basin area for asphalt pavement millings.

Table 7. Summary of layer coefficients for New Hampshire base courses.

Material	*#200 (%) In sand*	*#200 (%) In total*	*NHDOT*	*Back-calculation*	*Rohde*	*Clegg hammer*	*DCP*
Gravel	4.5	—	0.07	0.10	0.12	0.07	0.04
Crushed gravel (87% fracture)	6.9	—	0.10	0.12	0.13	—	0.07
Crushed stone (fine)	10.8	3.8	0.14	0.16	0.13	0.10	—
Crushed stone (coarse)	15.8	4.1	—	0.19	0.14	0.13	—
Reclaimed stabilized base (2%)	—	5.7	0.17	0.17	0.14	*	0.11
Reclaimed stabilized base (3%)	—	5.4	0.17	0.16	0.14	0.15	0.13
Reclaimed stabilized base (4%)	—	6.5	0.17	0.19	0.15	*	0.13
Reclaimed stabilized base (3% —2 lifts)	—	5.4	0.17	0.16	0.14	0.14	0.13
Asphalt concrete	—	—	0.34–0.38	—	0.37	—	—
Pavement milling	—	5.9	—	0.17	0.15	—	0.14

* unreasonable values.

amount of load required in maintaining a certain rate of needle penetration into the base course. The location of the needle in the test section will affect the test. The results from the test may reflect the strength of the fines in the test sections.

SUMMARY OF RESULTS

The layer coefficients, calculated in several ways, are listed in Table 7 with the exception of the in-situ CBR tests. Except for the gravel and crushed gravel, the back-calculated layer coefficients from WESDEF are higher than the others. It was noted that the error between values measured with the FWD and predicted deflections were approximately 20%. This will produce some errors in the final base course modulus. The back-calculated values using the FWD deflections (Rohde's method) appear to be close to those obtained from the Clegg and DCP data for the reclaimed stabilized base.

RECOMMENDATIONS

When the I-93 RSB test sections were built in 1992, the layer coefficient used for the RSB layer was 0.17. These pavements were found to deflect more than the existing pavement. Based on this observation and the results of this research, the values listed in Table 8 are the suggested layer coefficients for New Hampshire pavement materials.

The suggested values were based on the following decisions:

Table 8. Suggested layer coefficients for New Hampshire pavement materials.

Material	*Suggested* a_i
Gravel	0.10
Crushed gravel	0.12
Crushed stone (fine)	0.13
Crushed stone (coarse)	0.14
Reclaimed stabilized base (2%)	0.14
Reclaimed stabilized base (3%)	0.14
Reclaimed stabilized base (4%)	0.15
Reclaimed stabilized base (3%–2 lifts)	0.14
Asphalt concrete	0.37
Pavement milling	0.15

1. The layer coefficients obtained from the different methods were compared with the current NHDOT values. The Rohde values for the asphalt concrete were similar to the one used by the NHDOT. This gave confidence to the other layer coefficients obtained from the Rohde's method.

2. At this time, the layer coefficients obtained from the back-calculation procedure are questionable for two reasons. One, it was not possible to minimize the error between the calculated and measured deflections to below 10%, an acceptable COE standard. Second, the RSB back-calculated layer coefficients values were close to that used by NHDOT in the I-93 test section and the pavement deflections were high compared to the existing pavement. The expected deflections were supposed to be similar to the control test sections. However, the layer coefficient of the gravel from the back-calculation method was lower than that from Rohde's method. To be conservative, the lower value was chosen. For the crushed gravel the layer coefficients are similar from either method. Again the lower value was chosen. More FWD testing of existing roadway pavements is needed to develop confidence in the back-calculated values.

3. The layer coefficients from the Clegg hammer and the DCP are close to those obtained from the Rohde's method. This gives more confidence to the values suggested.

The structural performance between the one- and two-lift 3% RSB test sections could not be distinguished. It is recommended that cores be taken to determine if any segregation or bridging occurs during placement of thick RSB layers. Preliminary results from Quebec Ministry of Transportation indicate that the amount of reclaimed asphalt that can be used with the crushed gravel base must be limited to 30% by weight. When larger quantities are used, the strength of the layer appears to decrease. More studies in this area need to be conducted.

The layer coefficients presented here were determined for one subgrade modulus. The AASHTO design procedure uses a weighted subgrade modulus to reflect the seasonal effects on the subgrade. The layer coefficients from a weighted subgrade modulus may be lower. It is recommended that tests be conducted over one year to characterize the seasonal material performance.

Finally, if the suggested layer coefficients are used, a follow-up study should be conducted to determine the seasonal structural performance of the pavement structure. Test sections using the old and new layer coefficients need to be constructed and their structural performance monitored to validate these values. Additional testing will be needed to develop confidence in the back-calculated layer coefficients.

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APPENDIX A: GRAIN SIZE DISTRIBUTIONS OF TEST SECTION MATERIALS.

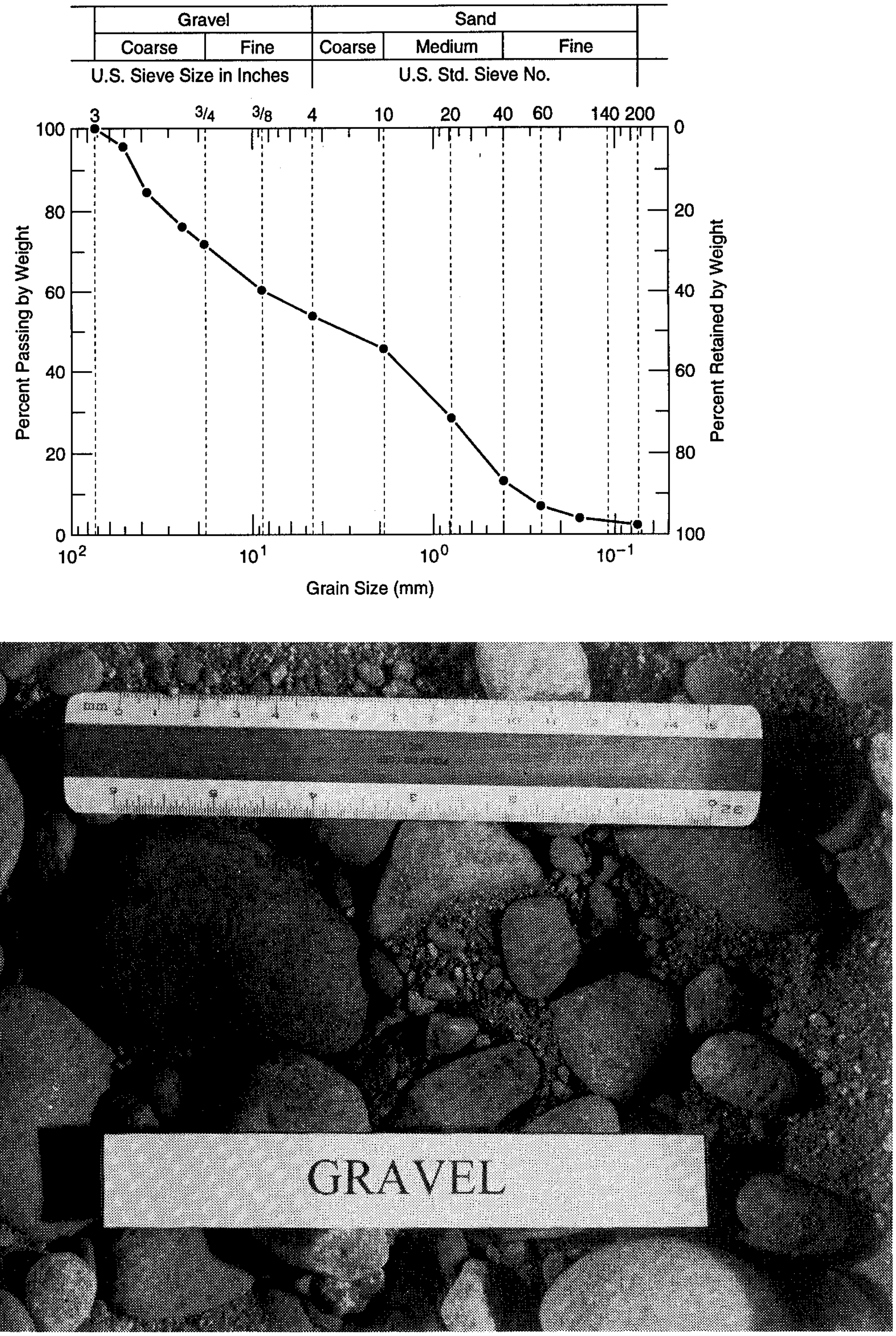
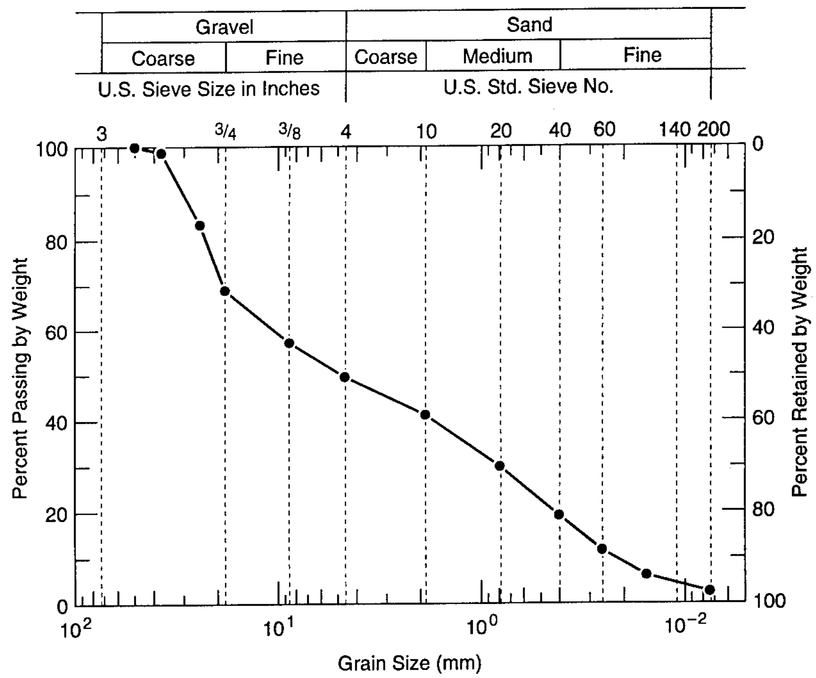


Figure A1. Grain size distribution of gravel.



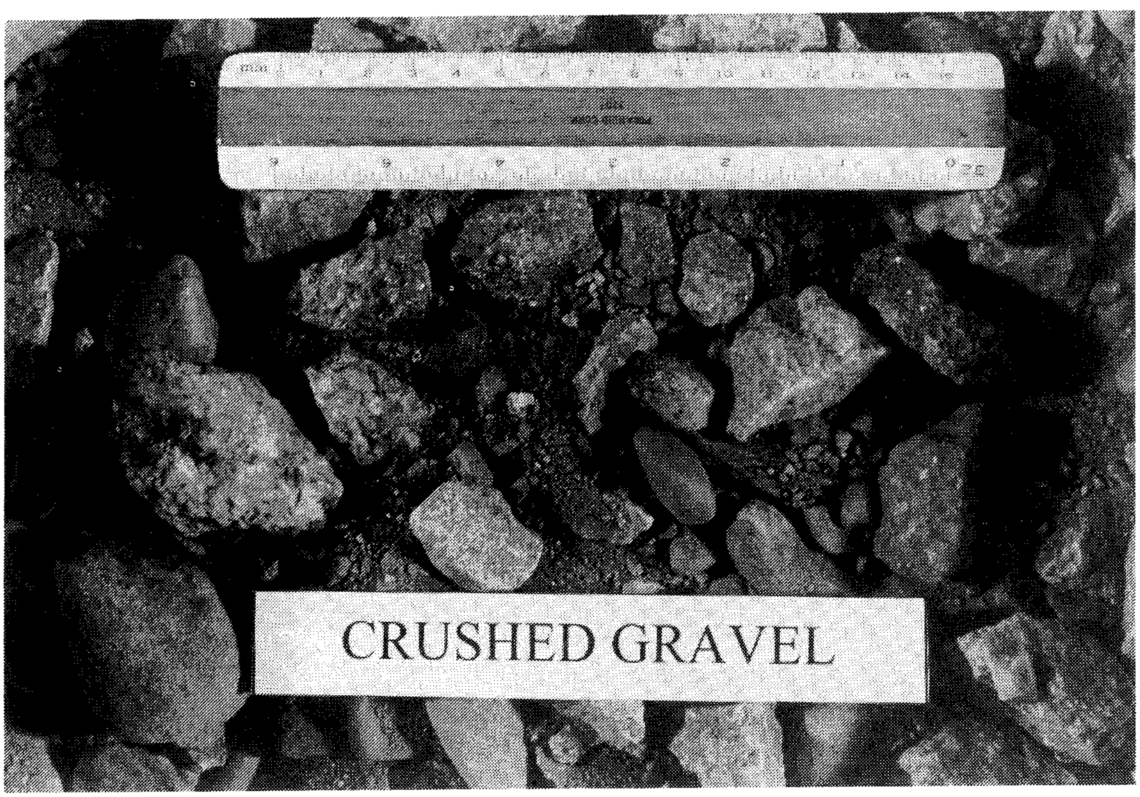
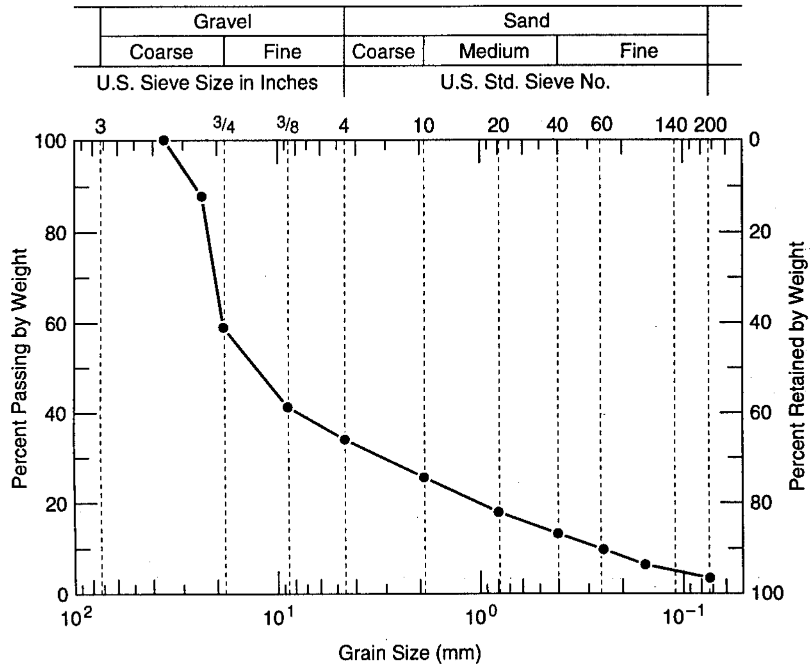


Figure A2. Grain size distribution of crushed gravel.



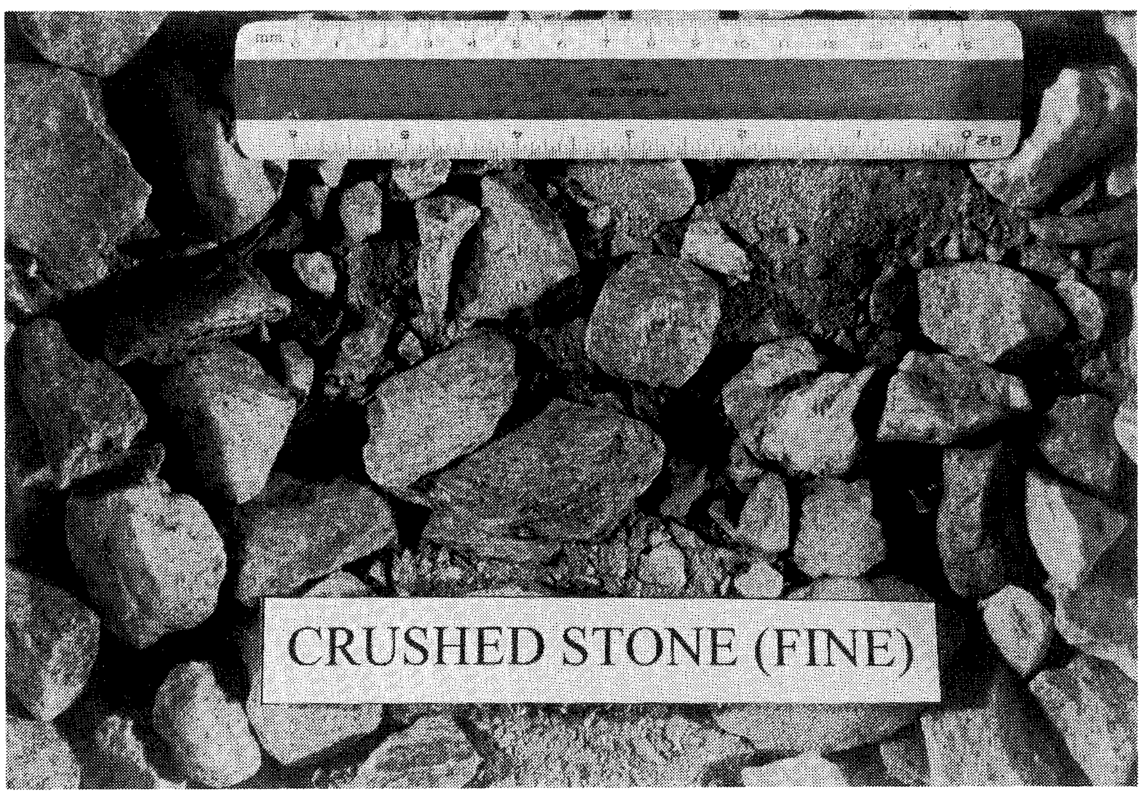
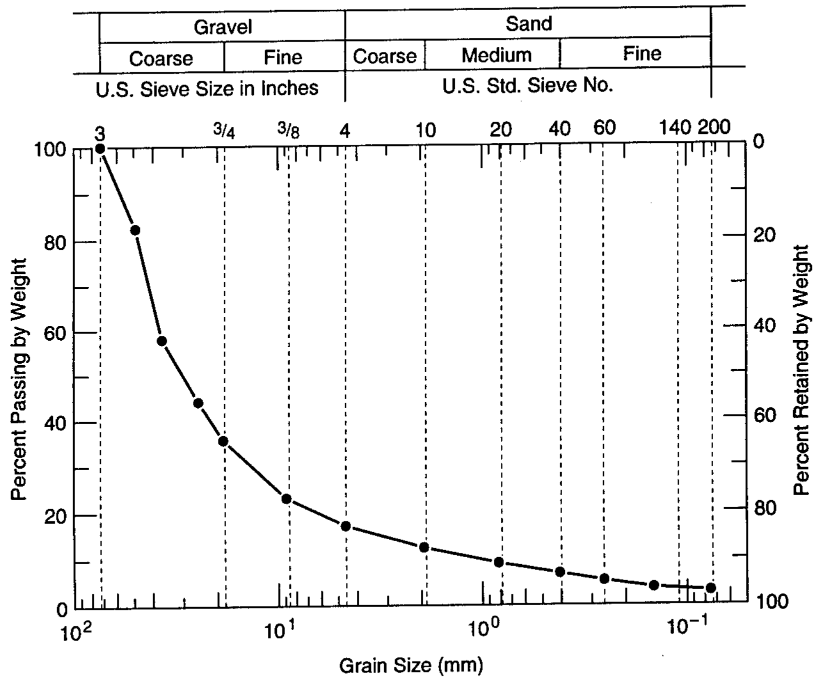


Figure A3. Grain size distribution of fine crushed stone.



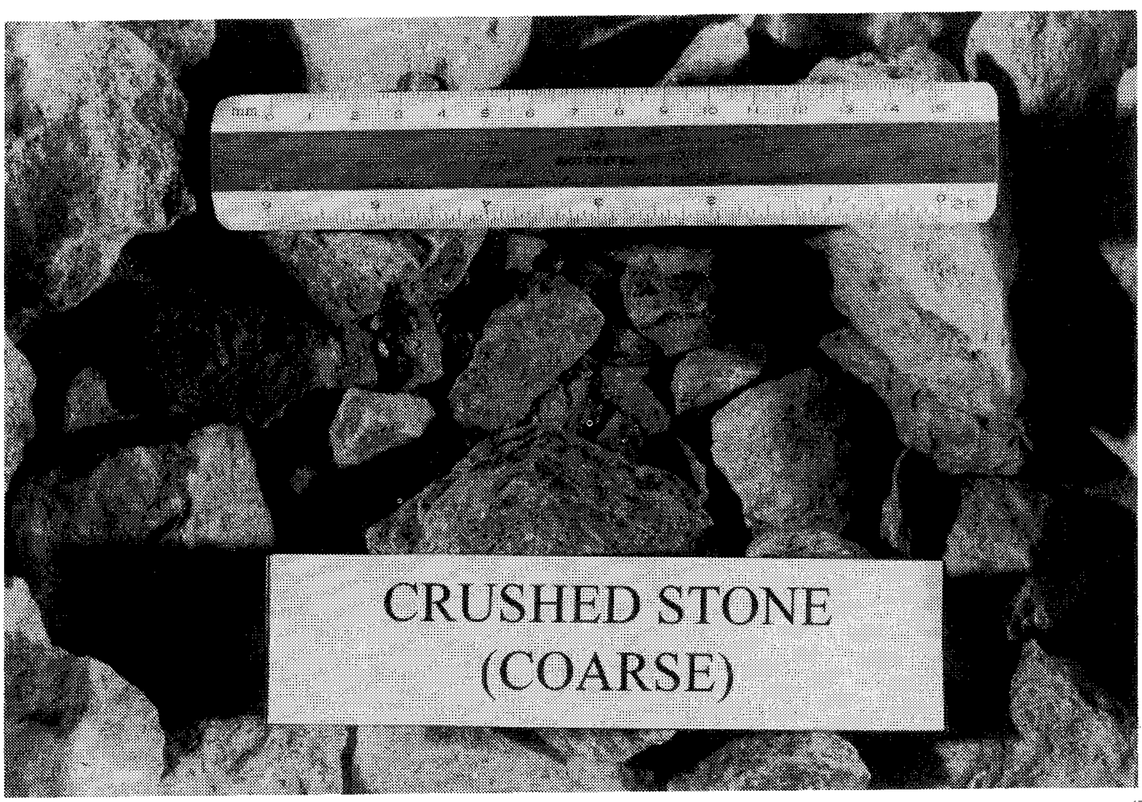


Figure A4. Grain size distribution of coarse crushed stone.

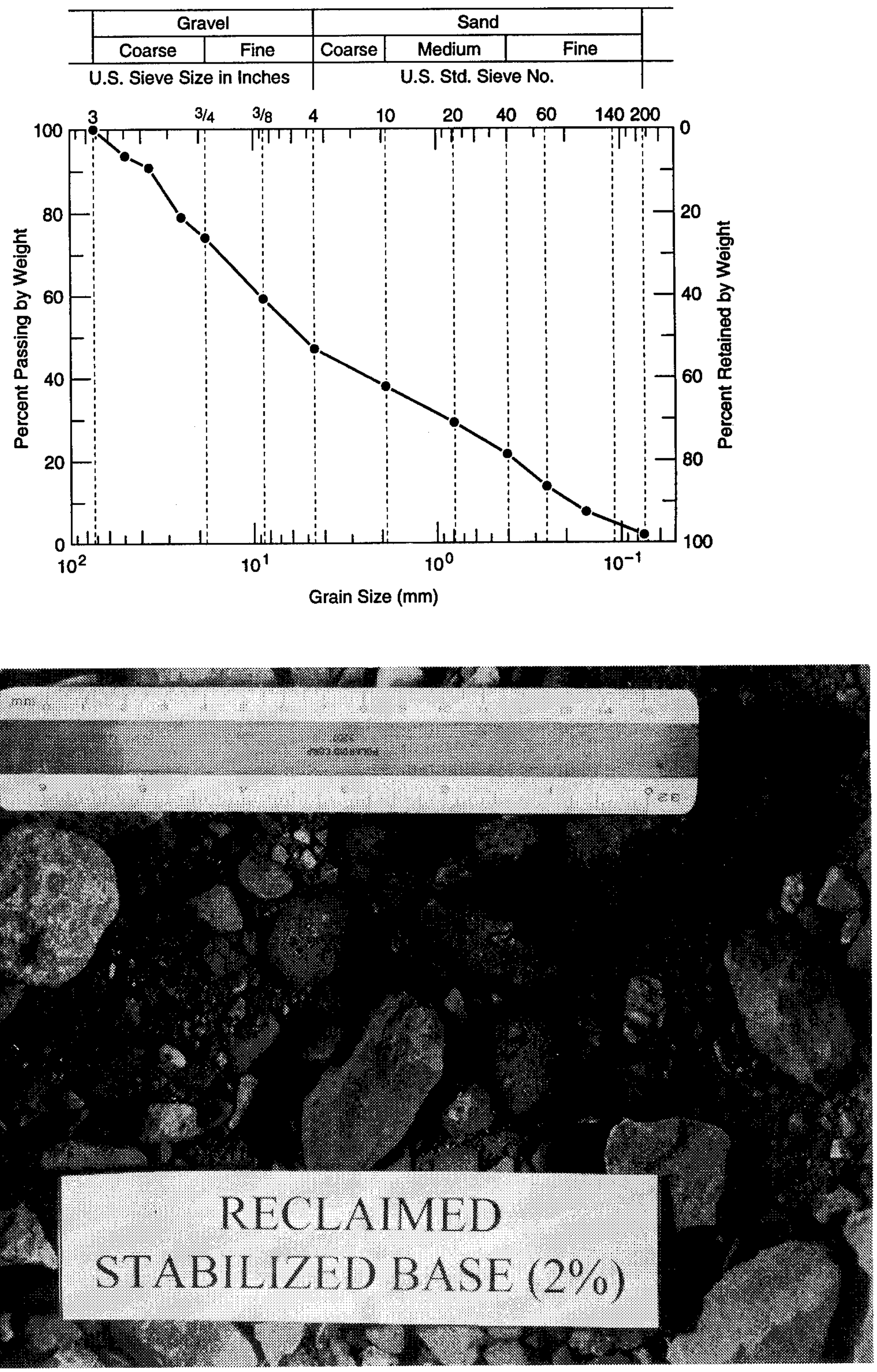


Figure A5. Grain size distribution of 2% RSB.

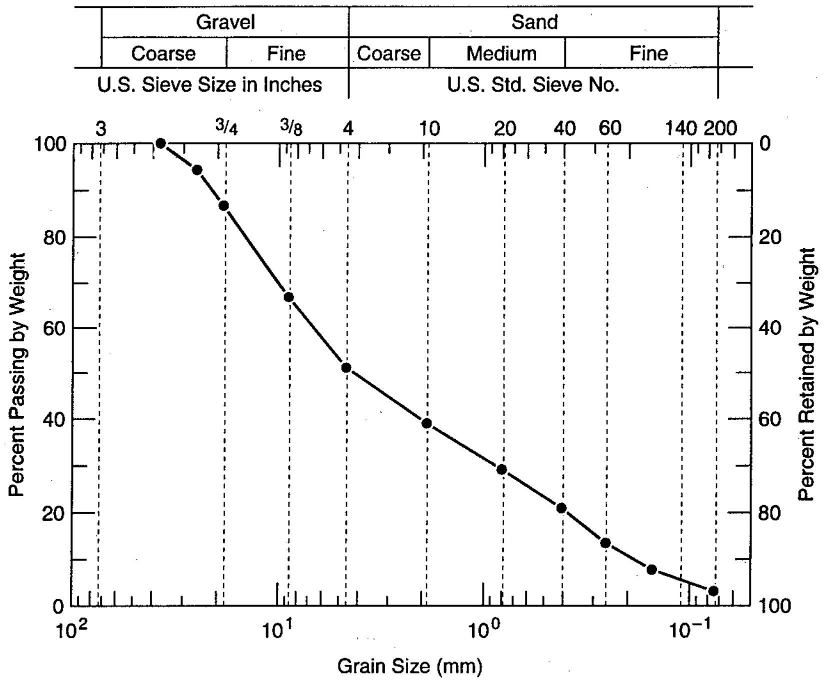


Figure A6. Grain size distribution of 3% RSB.

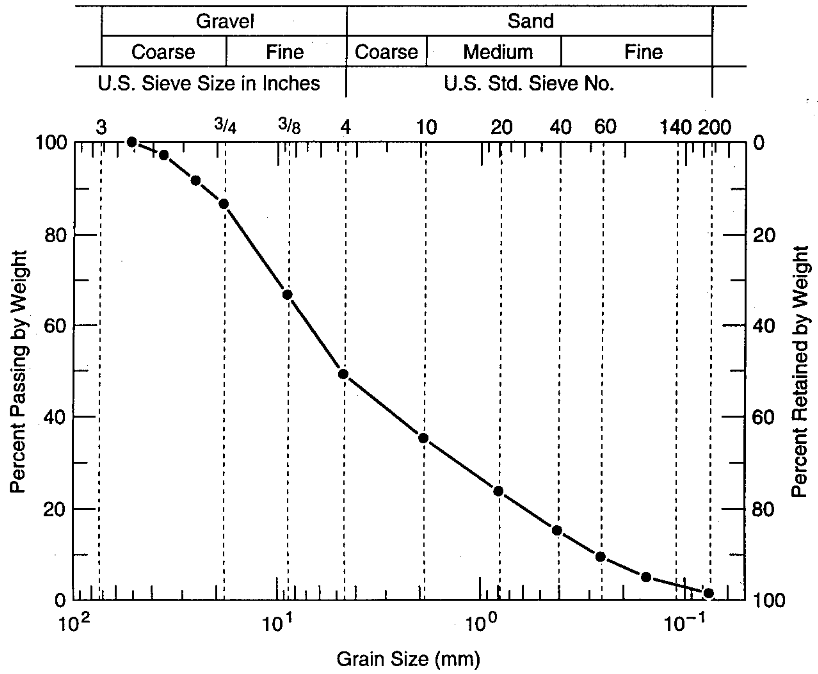


Figure A7. Grain size distribution of 4% RSB.

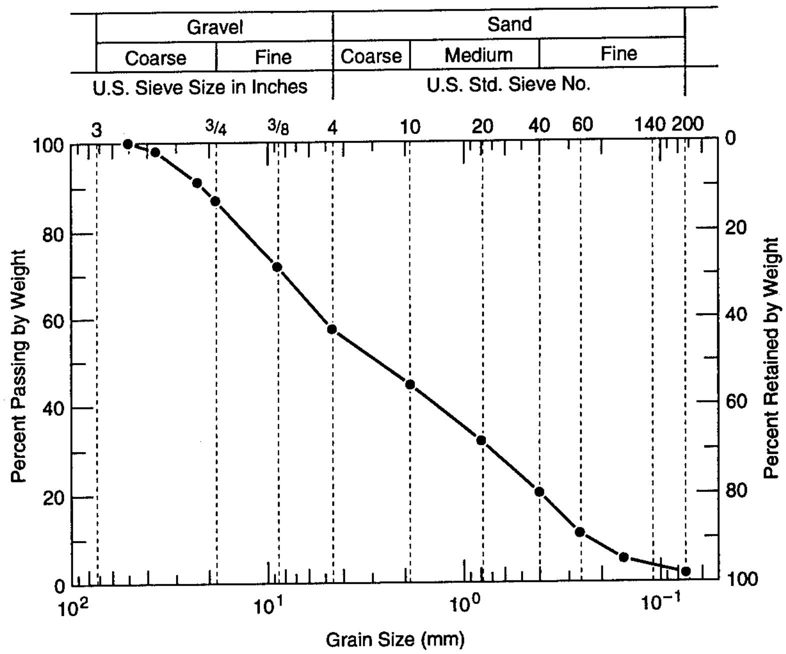
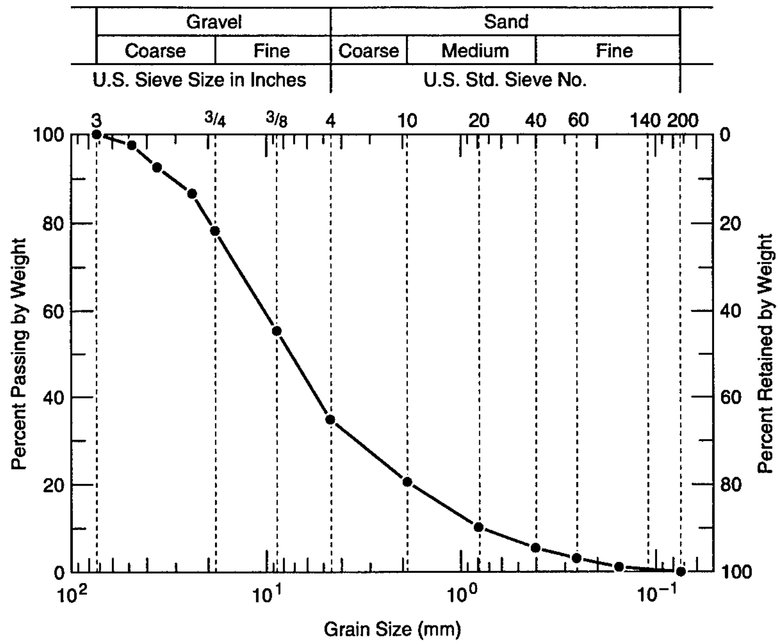


Figure A8. Grain size distribution of 3% RSB—two lifts.



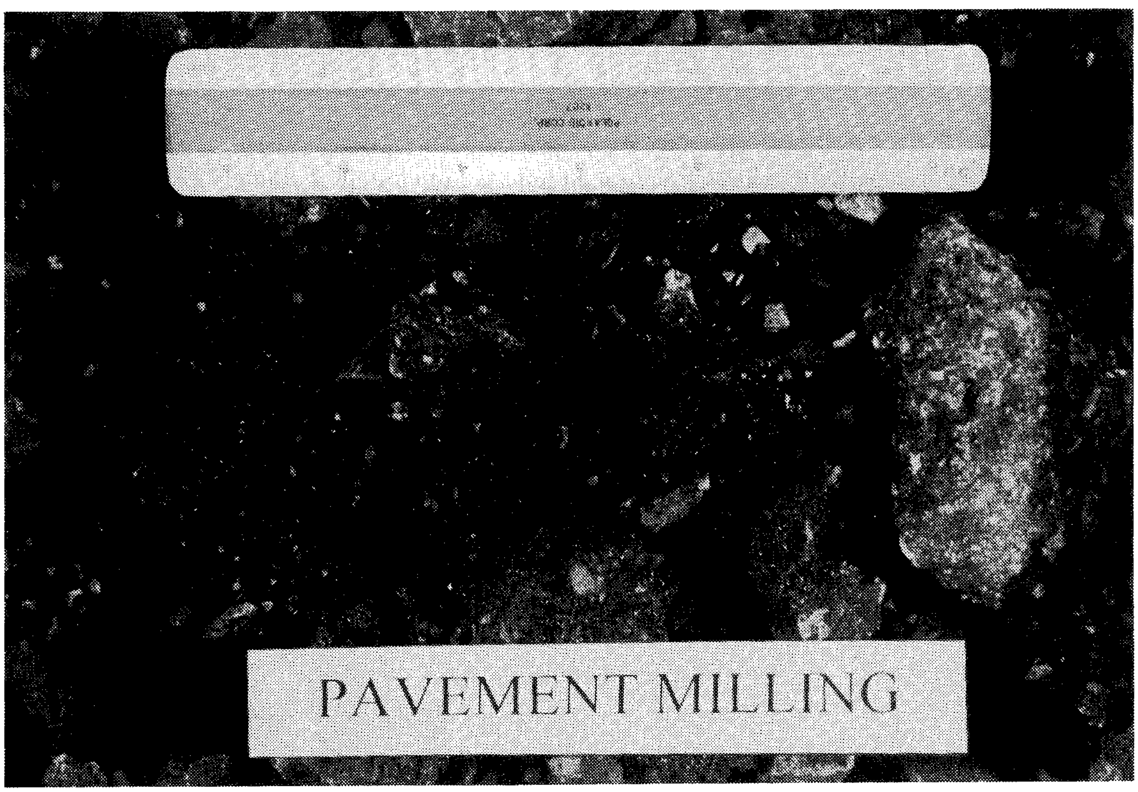


Figure A9. Grain size distribution of pavement millings.

APPENDIX B: NORMALIZED HWD DEFLECTION MEASUREMENTS.

Gravel

SEC	STA	DF1 mils	DF2 mils	DF3 mils	DF4 mils	DF5 mils	DF6 mils	DF7 mils	BASIN in^2
1	10	45.5	21.17	11.8	6.87	4.9	2.9	1.36	0.5220
1	15	43.44	18.15	12.38	7.68	4.59	2.46	1.15	0.4900
1	20	45.26	18.05	10.3	5.69	4.02	2.47	1.12	0.4690
1	25	43.37	19.62	10.57	5.62	3.79	2.19	1.13	0.4650
1	30	44.16	21.74	10.4	5.97	3.89	2.13	1.03	0.4810
1	35	37.41	19.78	10.46	4.69	3.4	1.98	1.08	0.4280
1	40	38.62	18.16	10.27	5.83	3.78	2.12	1.17	0.4360
1	45	42.07	27.9	12.64	6.46	4.55	2.31	1.13	0.5340
1	50	48.55	26.59	16.11	9.12	5.27	2.59	1.24	0.5980
1	55	44.98	22.86	14.26	9.08	5.91	2.94	2.17	0.5750
1	60	44.49	24.73	13.33	6.52	3.64	2.06	0.95	0.5130
1	65	44.66	24.61	13.92	6.73	3.74	2.06	1.04	0.5200
1	70	51.7	25.95	15.41	8.54	5.05	2.51	1.23	0.5960
1	75	49.83	30.24	11.64	6.4	4.53	2.06	1.04	0.5680
1	80	49.78	23.51	11.98	6.23	4.04	2.4	0.85	0.5270
1	85	63.95	34.56	21.47	12.34	6.83	2.94	1.65	0.7790
1	90	65.9	37.59	18.56	8.22	2.44	1.99	0.92	0.7000

Crushed Gravel

SEC	STA	DF1 mils	DF2 mils	DF3 mils	DF4 mils	DF5 mils	DF6 mils	DF7 mils	BASIN in^2
2	10	35.86	16.06	9.66	5.4	3.52	2.2	1.39	0.4090
2	15	38.39	20.47	12.23	6.8	4.77	2.42	1.22	0.4790
2	20	35.16	16.74	10.32	6.4	4.21	2.65	1.44	0.4340
2	25	35.89	19.84	11.22	6.25	4.11	2.53	1.34	0.4550
2	30	35.08	18.6	11.12	6.55	4.36	2.78	1.47	0.4540
2	35	36.93	20.82	11.42	6.49	4.3	2.65	1.45	0.4720
2	40	39.87	20.45	12.11	7.44	4.56	2.83	1.36	0.4960
2	45	42.89	23.57	14.89	8.56	5.55	3.04	1.54	0.5620
2	50	44.15	25.02	14	9.05	6.06	2.96	1.62	0.5780
2	55	42.83	27.41	16.03	8.78	5.01	2.87	1.39	0.5820
2	60	48.1	29.48	16.75	9.74	5.81	3.27	1.65	0.6420
2	65	46.85	26.93	14.23	7.41	4.66	2.86	1.35	0.5740
2	70	40.09	23.81	13.92	6.89	4.51	2.71	1.15	0.5170
2	75	46.07	26.11	15.53	8.5	4.99	2.83	1.5	0.5840
2	80	42.48	23.13	14.85	8.73	5.48	3.12	1.64	0.5600
2	85	52.55	31.56	20.47	10.92	6.35	3.12	1.88	0.7030
2	90	46.95	35.22	20	10.29	5.81	2.8	1.47	0.6810

Crushed Stone (Fine)

SEC	STA	DF1 mils	DF2 mils	DF3 mils	DF4 mils	DF5 mils	DF6 mils	DF7 mils	BASIN in^2
3	10	40	19.4	11.24	6.84	4.46	2.7	1.36	0.4790
3	15	39.33	21.95	11.32	6.24	3.98	2.23	1.35	0.4750
3	20	40.5	22.27	12.56	7.28	4.63	2.82	1.38	0.5110
3	25	35.43	18.59	10.31	5.43	3.47	2.19	1.13	0.4220
3	30	36.68	20.55	11.15	6.47	3.72	2.23	1.26	0.4530
3	35	38.7	20.14	10.99	6.13	3.9	2.42	1.2	0.4600
3	40	39.91	22.72	12.48	6.76	4.23	2.43	1.2	0.4950
3	45	39.14	21.9	11.94	7.2	4.78	2.84	1.36	0.5010
3	50	43.12	21.47	13.13	6.59	4.04	2.49	1.31	0.5030
3	55	40.98	23.54	12.76	7.61	5.09	2.59	1.37	0.5230
3	60	59.39	41.77	21.7	10.93	5.94	2.99	1.56	0.7880
3	65	52.76	36.1	18.77	10.12	6.14	3.1	1.35	0.7090
3	70	51.01	30.37	18.53	10.39	6.59	2.97	1.36	0.6700
3	75	53.89	29.35	16.31	7.66	3.74	1.99	1.42	0.6060
3	80	39.67	25.84	13.41	6.85	3.96	2.25	1.21	0.5130
3	85	65.9	44.71	25.75	13.32	7.04	2.89	1.39	0.8730
3	90	62.12	40.97	24.69	12.21	6.48	3.07	1.34	0.8210

Crushed Stone (Coarse)

SEC	STA	DF1 mils	DF2 mils	DF3 mils	DF4 mils	DF5 mils	DF6 mils	DF7 mils	BASIN in^2
4	10	35.83	21.65	14.32	8.06	4.95	2.41	1.32	0.4970
4	15	32.59	23.05	13.85	8.06	5.03	2.88	1.38	0.5000
4	20	35.31	23.24	13.96	8.27	5.19	2.77	1.34	0.5130
4	25	38.15	24.25	13.92	7.98	4.9	2.73	1.35	0.5250
4	30	36.24	22.2	12.47	7.39	4.59	2.57	1.43	0.4900
4	35	34.73	22.14	13.35	7.97	4.8	2.66	1.38	0.4940
4	40	37.72	23.37	15.07	8.67	5.57	3.2	1.7	0.5460
4	45	41.75	28.98	18.13	10.15	5.98	3.17	1.71	0.6240
4	50	37.95	24.33	16.53	9.73	5.76	3.08	1.63	0.5660
4	55	39.26	24.93	15.73	8.49	4.98	2.57	1.2	0.5420
4	60	39.02	24.89	13.68	6.02	3.25	1.99	1.14	0.4890
4	65	34.94	23.4	15.23	8.21	5.48	2.74	1.23	0.5190
4	70	35.52	18.81	9.48	4.98	3.73	2.55	1.2	0.4260
4	75	42.27	29.8	17.54	8.44	4.65	2.46	1.25	0.5870
4	80	55.75	34.88	22.66	12.37	6.52	2.69	1.83	0.7490
4	85	57.56	38.53	22.12	9.48	5.08	2.85	1.36	0.7420
4	90	56.83	39.13	20.63	11.46	6.11	3.23	1.31	0.7630

Reclaimed Stabilized Base (2%)

SEC	STA	DF1 mils	DF2 mils	DF3 mils	DF4 mils	DF5 mils	DF6 mils	DF7 mils	BASIN in^2
5	10	32.32	20.17	12.62	7.56	4.72	2.55	1.36	0.4630
5	15	33.79	22.68	14	8.14	5.19	2.65	1.35	0.5010
5	20	34.39	19.93	12.71	7.99	4.94	2.65	1.17	0.4750
5	25	30.05	13.37	9.08	5.5	3.62	2.16	1.31	0.3660
5	30	30.58	17.68	11.17	6.51	4.08	2.41	1.48	0.4210
5	35	31.16	18.87	12.08	6.97	4.29	2.42	1.35	0.4380
5	40	33.33	20.62	14.15	8.36	4.98	2.6	1.39	0.4860
5	45	33.42	19.77	13.27	8.05	4.91	2.68	1.4	0.4760
5	50	34.53	21.47	12.99	7.49	4.58	2.44	1.37	0.4780
5	55	35.07	19.91	12.99	7.47	4.41	2.39	1.3	0.4680
5	60	39.38	24.67	15.86	8.93	5.07	2.49	1.34	0.5450
5	65	38.8	24.16	15.74	8.77	4.93	2.51	1.41	0.5380
5	70	40.94	24.36	16.22	9.4	5.47	2.83	1.51	0.5660
5	75	37.46	24.52	16	9.7	5.45	2.55	1.34	0.5460
5	80	39.26	25.59	16.71	9.41	5.44	2.56	1.4	0.5620
5	85	36.12	23.35	14.38	8.58	5.14	2.9	1.59	0.5260
5	90	33.12	23.32	14.37	8.54	5.37	2.99	1.17	0.5120

Reclaimed Stabilized Base (3%)

SEC	STA	DF1 mils	DF2 mils	DF3 mils	DF4 mils	DF5 mils	DF6 mils	DF7 mils	BASIN in^2
6	10	34.29	20.62	13.09	7.51	4.35	2.22	1.22	0.4650
6	15	30.2	16.34	10.39	6.21	3.91	2.26	1.37	0.4000
6	20	33.65	20.33	13.24	7.55	4.28	2.42	1.3	0.4660
6	25	40.02	21.99	14.17	8.19	4.97	2.59	1.35	0.5200
6	30	34.1	18.23	11.68	6.62	4.03	2.36	1.34	0.4390
6	35	34.98	20.12	13.01	7.34	4.36	2.59	1.44	0.4730
6	40	34.35	21.2	13.8	7.74	4.77	2.76	1.57	0.4920
6	45	36.54	21.53	14.14	8.61	5.23	2.88	1.63	0.5160
6	50	36.28	22.52	14.98	9.08	5.81	3.31	1.76	0.5430
6	55	38.46	24.27	15.9	8.94	5.11	2.71	1.48	0.5450
6	60	35.08	22.12	13.79	7.25	4.28	2.41	1.46	0.4850
6	65	35.5	22.4	14.13	7.45	4.43	2.49	1.44	0.4940
6	70	33.84	22.22	14.1	7.88	4.54	2.53	1.29	0.4880
6	75	39.2	23.37	14.33	8.13	5	2.68	1.48	0.5290
6	80	46.59	28.45	17.83	10.42	6.18	3.16	1.57	0.6400
6	85	37.71	23.67	14.8	8.37	4.98	2.59	1.48	0.5260
6	90	34.74	21.68	13.6	7.72	4.66	2.56	1.42	0.4880

Reclaimed Stabilized Base (4%)

SEC	STA	DF1 mils	DF2 mils	DF3 mils	DF4 mils	DF5 mils	DF6 mils	DF7 mils	BASIN in^2
7	10	31.31	21.69	14.16	8.53	5.14	2.56	1.42	0.4870
7	15	30.96	17.78	12.08	7.27	4.5	2.55	1.38	0.4370
7	20	28.62	18.74	12.45	7.27	4.39	2.42	1.41	0.4330
7	25	32.17	20.14	13.66	7.82	4.6	2.5	1.59	0.4700
7	30	32.52	22.16	14.45	8.5	4.89	2.35	1.26	0.4880
7	35	31.7	21.41	14.62	8.92	5.48	2.76	1.48	0.4990
7	40	31.05	21.09	14.45	9	5.56	2.95	1.51	0.4980
7	45	36.21	23.16	15.87	9.44	5.67	2.79	1.47	0.5390
7	50	35.41	23.13	16.09	9.48	5.29	2.7	1.44	0.5310
7	55	33.97	22.81	15.37	9.17	5.3	2.57	1.37	0.5150
7	60	32.78	18.38	12.29	7.31	4.75	2.63	1.35	0.4530
7	65	31.78	21.11	14.79	9.23	5.55	2.68	1.42	0.4980
7	70	31.77	21.81	14.98	8.89	5.32	2.76	1.48	0.5020
7	75	36.28	23.32	15.49	8.96	5.21	2.51	1.22	0.5230
7	80	34.4	21.94	15.25	9.19	5.47	2.7	1.41	0.5150
7	85	35.96	23.07	15.33	8.96	5.4	2.83	1.47	0.5300
7	90	33.64	24.34	16.77	10.2	5.91	2.79	1.4	0.5460

Reclaimed Stabilized Base (3% - 2 lifts)

SEC	STA	DF1 mils	DF2 mils	DF3 mils	DF4 mils	DF5 mils	DF6 mils	DF7 mils	BASIN in^2
8	10	38	23.55	14.57	8.61	5.46	2.99	1.46	0.5380
8	15	37.53	20.24	13.55	8.1	4.94	2.61	1.4	0.4960
8	20	39.04	24.89	15.68	8.69	4.88	2.38	1.27	0.5380
8	25	33.52	20.27	12.62	7.26	4.41	2.25	1.29	0.4580
8	30	35.84	20.82	13.13	7.48	4.46	2.26	1.31	0.4750
8	35	33.78	20.26	12.92	7.8	4.87	2.44	1.31	0.4720
8	40	38.65	24.94	15.18	8.07	4.5	2.36	1.33	0.5270
8	45	30.13	18.27	11.66	7.06	4.48	2.42	1.4	0.4310
8	50	33.43	21.77	14.25	8.67	5.31	2.89	1.63	0.5070
8	55	37.84	22.22	15.37	9.23	5.49	2.89	1.55	0.5370
8	60	32.54	18.55	11.6	6.87	4.27	2.52	1.42	0.4410
8	65	41.93	28.63	17.16	8.87	5.38	2.83	1.52	0.5960
8	70	41.84	27.11	16.92	9.31	5.48	2.69	1.33	0.5840
8	75	38.57	23.65	13.39	7.16	4.23	2.25	1.26	0.5000
8	80	50.68	34.15	21.74	11.22	5.77	2.46	1.39	0.6970
8	85	61.95	41.31	25.12	12.08	5.95	2.62	1.44	0.8120
8	90	53.55	33.7	18	8.87	4.62	2.33	1.36	0.6590

Asphalt Concrete

SEC	STA	DF1 mils	DF2 mils	DF3 mils	DF4 mils	DF5 mils	DF6 mils	DF7 mils	BASIN in^2
9	10	10.99	9.27	8.1	6.63	5.23	3.17	1.22	0.2990
9	15	9.35	8.09	7.11	5.81	4.51	2.71	1	0.2580
9	20	10.51	8.97	7.8	6.27	4.71	2.64	1	0.2740
9	25	11.39	9.49	7.95	6.17	4.48	2.4	0.99	0.2750
9	30	10.49	8.74	7.41	5.77	4.22	2.29	0.88	0.2560
9	35	11	8.97	7.61	5.94	4.39	2.35	0.91	0.2640
9	40	11.21	9.26	7.78	6.1	4.44	2.45	0.99	0.2720
9	45	10.9	8.93	7.61	6.03	4.46	2.45	0.95	0.2670
9	50	10.33	8.28	6.99	5.45	4.01	2.25	0.92	0.2460
9	55	9.52	7.78	6.7	5.34	3.97	2.19	0.79	0.2350
9	60	8.66	7.03	6.03	4.78	3.57	2.03	0.78	0.2140
9	65	8.23	6.83	5.96	4.83	3.68	2.13	0.85	0.2140
9	70	7.49	6.07	5.28	4.28	3.29	1.96	0.79	0.1930
9	75	7.31	5.64	4.94	4.04	3.12	1.92	0.83	0.1850
9	80	8.4	6.56	5.72	4.7	3.66	2.22	0.93	0.2140
9	85	9.16	7.89	6.96	5.68	4.45	2.71	1.09	0.2550
9	90	8.4	7.31	6.47	5.39	4.26	2.66	1.06	0.2410

Pavement Milling

SEC	STA	DF1 mils	DF2 mils	DF3 mils	DF4 mils	DF5 mils	DF6 mils	DF7 mils	BASIN in^2
10	10	36.57	22.18	15.43	9.15	5.3	2.69	1.43	0.5250
10	15	33.97	22.76	15.14	8.5	4.83	2.48	1.38	0.5040
10	20	33.43	22.14	15.41	9.36	5.4	2.43	1.26	0.5070
10	25	32.03	21.82	14.45	8.42	4.78	2.31	1.19	0.4810
10	30	34.98	24.6	16.7	9.8	5.25	2.34	1.19	0.5340
10	35	31.16	20.63	13.88	8.14	4.66	2.29	1.33	0.4660
10	40	39.32	23.67	15.18	7.99	4.14	2.12	1.25	0.5140
10	45	31.01	20.43	13.65	7.56	4.39	2.38	1.25	0.4580
10	50	36.71	23.94	15.82	9.17	5.06	2.34	1.39	0.5290
10	55	36.18	23.65	16.61	9.78	5.31	2.61	1.43	0.5400
10	60	32.74	22.46	15.55	9.48	5.51	2.77	1.46	0.5170
10	65	29.42	18.75	12.73	7.64	4.56	2.41	1.35	0.4400
10	70	34.56	22.91	15.21	8.27	4.34	2.31	1.38	0.4990
10	75	32.91	19.52	13.15	7.76	4.5	2.35	1.27	0.4590
10	80	29.68	18.2	12.11	6.72	3.84	2.04	1.11	0.4130
10	85	33.21	21.76	15.16	8.83	5	2.47	1.32	0.4970
10	90	26.51	20.18	14.06	8.83	5.3	2.43	1.26	0.4570

Subgrade

SEC	STA	DF1 mils	DF2 mils	DF3 mils	DF4 mils	DF5 mils	DF6 mils	DF7 mils	BASIN in^2
1	10	35.3	14.7	8.0	5.3	2.9	1.9	1.3	0.5053
1	15	30.8	12.2	6.3	4.1	2.1	1.5	1.1	0.4201
1	20	31.5	14.4	7.1	4.4	2.2	1.6	1.2	0.4542
1	25	30.5	11.5	5.9	3.9	2.2	1.6	1.1	0.4077
1	30	26.0	10.5	5.2	3.3	1.9	1.4	1.1	0.3565
1	35	27.1	8.9	4.2	2.6	1.7	1.3	0.9	0.3333
1	40	22.9	8.8	4.9	3.3	2.0	1.4	1.1	0.3240
1	45	28.7	12.4	7.0	4.5	2.3	1.7	1.3	0.4216
1	50	37.0	17.4	9.9	5.8	2.6	1.7	1.2	0.5487
1	55	37.9	15.2	6.9	4.4	2.4	1.7	1.3	0.5007
1	60	32.1	11.6	4.8	2.8	1.7	1.3	1.0	0.3937
1	65	35.4	13.1	5.8	3.4	1.9	1.5	1.1	0.4433
1	70	44.2	19.7	8.8	5.2	2.6	1.7	1.2	0.6014
1	75	47.0	21.8	10.5	5.2	1.7	1.2	0.9	0.6262
1	80	43.6	20.5	8.4	4.2	1.9	1.3	1.0	0.5797
1	85	53.5	25.3	11.5	6.5	2.9	2.1	1.6	0.7456
1	90	53.8	20.7	7.9	4.5	2.4	1.7	1.3	0.6526

Subgrade

SEC	STA	DF1 mils	DF2 mils	DF3 mils	DF4 mils	DF5 mils	DF6 mils	DF7 mils	BASIN in^2
2	10	27.7	11.5	6.3	3.9	2.2	1.7	1.3	0.3968
2	15	25.4	11.5	6.0	4.1	2.2	1.7	1.4	0.3844
2	20	30.2	11.2	5.7	3.8	2.2	1.6	1.2	0.4046
2	25	24.1	9.0	5.7	3.7	2.2	1.7	1.3	0.3488
2	30	24.8	10.6	5.7	4.0	2.4	1.9	1.4	0.3751
2	35	33.6	13.5	6.9	4.1	2.2	1.7	1.3	0.4557
2	40	39.5	14.8	7.4	4.6	2.4	1.7	1.4	0.5131
2	45	42.1	18.7	9.6	5.6	2.8	2.0	1.6	0.5952
2	50	44.4	14.5	7.0	4.2	2.3	1.7	1.5	0.5332
2	55	44.5	19.3	7.2	4.1	2.0	1.6	1.2	0.5720
2	60	61.4	27.0	12.0	6.5	2.8	1.9	1.5	0.8076
2	65	53.2	21.1	9.1	5.0	2.6	1.7	1.2	0.6665
2	70	35.7	14.6	6.9	4.1	2.2	1.6	1.2	0.4759
2	75	36.3	15.6	7.4	4.4	2.3	1.7	1.5	0.4991
2	80	45.9	20.8	10.2	5.9	3.0	2.2	1.6	0.6479
2	85	67.8	26.3	11.0	5.9	2.8	2.0	1.6	0.8308
2	90	72.8	18.4	7.4	4.3	2.3	1.5	1.1	0.7378

Subgrade

SEC	STA	DF1 mils	DF2 mils	DF3 mils	DF4 mils	DF5 mils	DF6 mils	DF7 mils	BASIN in^2
3	10	33.2	14.0	7.4	4.3	2.4	1.8	1.3	0.4650
3	15	33.0	14.3	6.6	4.0	2.2	1.8	1.3	0.4573
3	20	35.4	11.8	5.8	3.7	2.2	1.7	1.3	0.4418
3	25	28.3	9.9	4.5	2.9	1.9	1.4	1.1	0.3581
3	30	25.1	10.0	4.8	3.1	1.9	1.5	1.1	0.3457
3	35	30.6	10.7	5.6	3.5	1.9	1.5	1.1	0.3922
3	40	33.0	13.6	6.7	4.0	2.1	1.6	1.1	0.4464
3	45	32.3	14.7	7.7	4.8	2.7	1.9	1.5	0.4790
3	50	37.1	12.4	5.7	3.7	2.2	1.7	1.3	0.4557
3	55	35.1	15.9	7.8	4.4	2.0	1.5	1.3	0.4898
3	60	71.3	28.0	11.0	5.2	2.2	1.6	1.3	0.8463
3	65	48.4	20.1	8.9	5.2	2.6	1.8	1.3	0.6309
3	70	55.1	26.0	11.0	5.6	2.5	1.7	1.3	0.7394
3	75	59.7	18.0	3.0	2.2	1.9	1.5	1.2	0.6061
3	80	52.2	18.8	7.8	4.4	2.2	1.5	1.1	0.6200
3	85	66.5	26.9	10.4	5.6	2.5	1.7	1.3	0.8107
3	90	73.1	16.5	6.7	4.1	2.3	1.7	1.3	0.7192

Subgrade

SEC	STA	DF1 mils	DF2 mils	DF3 mils	DF4 mils	DF5 mils	DF6 mils	DF7 mils	BASIN in^2
4	10	38.9	17.2	7.6	4.4	2.3	1.6	1.2	0.5270
4	15	43.6	15.9	6.7	4.4	2.4	1.7	1.3	0.5425
4	20	41.1	18.5	8.9	5.3	3.0	1.6	1.3	0.5751
4	25	48.7	18.7	7.5	4.1	2.3	1.7	1.3	0.5968
4	30	34.5	15.0	7.8	4.6	2.6	2.0	1.5	0.4945
4	35	36.6	13.9	6.9	4.3	2.4	1.7	1.4	0.4821
4	40	48.2	18.1	9.3	5.1	2.8	1.9	1.3	0.6200
4	45	53.2	21.9	9.7	5.6	2.9	2.0	1.5	0.6929
4	50	45.7	16.3	7.7	4.5	2.4	1.7	1.4	0.5658
4	55	43.5	18.9	8.7	4.4	2.3	1.7	1.3	0.5797
4	60	57.6	16.2	4.1	2.0	1.6	1.3	1.1	0.5751
4	65	49.0	12.6	7.0	4.4	2.2	1.7	1.3	0.5425
4	70	46.4	12.4	4.4	3.2	2.2	1.5	1.1	0.4976
4	75	50.5	19.7	7.5	4.0	2.0	1.4	1.1	0.6092
4	80	81.1	34.0	13.0	6.5	2.0	1.5	1.1	0.9781
4	85	83.1	19.2	5.6	3.5	2.0	1.8	1.1	0.7890
4	90	52.0	16.2	7.4	4.3	2.4	1.9	1.4	0.5999

Subgrade SEC	STA	DF1 mils	DF2 mils	DF3 mils	DF4 mils	DF5 mils	DF6 mils	DF7 mils	BASIN in^2
5	10	44.5	16.8	8.2	4.6	2.4	1.7	1.5	0.5673
5	15	39.7	16.3	7.8	4.7	2.5	1.7	1.3	0.5332
5	20	43.7	17.3	8.6	4.7	2.0	1.4	1.3	0.5611
5	25	29.8	10.2	4.8	3.1	2.0	1.5	1.2	0.3782
5	30	36.1	13.3	6.3	4.0	2.5	1.9	1.4	0.4712
5	35	41.3	17.4	6.4	3.8	2.4	1.8	1.5	0.5363
5	40	52.0	21.5	10.2	5.1	2.6	2.0	1.3	0.6743
5	45	49.2	18.0	7.6	4.3	2.5	1.9	1.5	0.6030
5	50	50.9	15.3	6.3	3.6	2.3	1.8	1.3	0.5704
5	55	49.4	16.4	6.1	3.6	2.3	1.7	1.3	0.5689
5	60	62.7	17.5	6.7	3.9	2.2	1.6	1.3	0.6619
5	65	56.2	21.3	8.1	3.9	2.3	1.8	1.4	0.6696
5	70	67.1	24.1	9.8	5.4	2.6	1.9	1.5	0.7890
5	75	51.7	19.3	7.8	5.7	2.2	1.7	1.4	0.6371
5	80	94.1	16.1	7.6	4.6	2.5	1.9	1.5	0.8587
5	85	70.9	16.7	7.6	4.7	2.9	2.2	1.8	0.7363
5	90	66.6	15.2	8.3	5.5	3.4	2.5	1.8	0.7177

Subgrade SEC	STA	DF1 mils	DF2 mils	DF3 mils	DF4 mils	DF5 mils	DF6 mils	DF7 mils	BASIN in^2
6	10	50.6	19.7	8.7	4.6	2.2	1.6	1.2	0.6278
6	15	46.4	15.4	6.4	3.5	1.9	1.5	1.1	0.5348
6	20	52.0	19.4	9.1	4.5	2.2	1.6	1.3	0.6340
6	25	52.4	16.1	7.1	4.1	2.2	1.7	1.3	0.5937
6	30	40.6	16.1	7.0	3.9	2.2	1.6	1.2	0.5193
6	35	38.4	16.9	7.6	4.2	2.2	1.7	1.3	0.5208
6	40	44.4	20.2	8.3	4.8	2.6	1.9	1.4	0.6045
6	45	42.3	17.2	8.6	5.2	2.7	2.0	1.6	0.5720
6	50	45.3	23.1	10.2	6.1	3.4	2.5	1.9	0.6774
6	55	55.0	24.7	10.0	5.3	2.7	2.0	1.5	0.7270
6	60	51.4	19.2	7.2	4.0	2.2	1.7	1.3	0.6154
6	65	41.0	17.2	7.7	4.2	2.2	1.7	1.3	0.5410
6	70	50.5	22.3	9.2	5.1	2.7	2.0	1.6	0.6696
6	75	52.7	19.1	6.7	4.2	2.5	2.0	1.5	0.6278
6	80	63.5	19.9	8.1	4.6	2.8	2.0	1.5	0.7161
6	85	60.6	16.5	8.3	4.9	2.6	1.9	1.5	0.6696
6	90	46.9	13.4	7.0	4.5	2.6	1.9	1.4	0.5472

Subgrade

SEC	STA	DF1 mils	DF2 mils	DF3 mils	DF4 mils	DF5 mils	DF6 mils	DF7 mils	BASIN in^2
7	10	41.2	15.9	8.1	5.0	2.6	1.9	1.5	0.5472
7	15	38.9	15.3	6.9	4.4	2.6	1.8	1.3	0.5131
7	20	33.4	14.3	6.9	4.0	2.2	1.7	1.4	0.4619
7	25	36.7	13.7	5.8	3.8	2.3	1.7	1.3	0.4697
7	30	43.5	17.2	7.8	4.1	2.1	1.7	1.3	0.5534
7	35	47.6	20.0	9.6	6.1	2.7	1.9	1.6	0.6417
7	40	41.7	18.3	8.9	5.4	2.8	2.0	1.5	0.5828
7	45	44.2	17.6	8.2	5.2	2.7	1.9	1.5	0.5828
7	50	47.6	16.2	7.5	4.4	2.6	2.0	1.5	0.5797
7	55	45.0	16.7	7.5	4.5	2.6	1.9	1.4	0.5673
7	60	41.3	15.6	7.2	4.5	2.4	1.7	1.3	0.5301
7	65	43.9	13.7	8.0	4.7	2.5	1.8	1.5	0.5379
7	70	42.8	18.1	9.1	5.6	3.1	2.2	1.5	0.5968
7	75	55.3	18.9	8.1	4.3	2.3	1.8	1.4	0.6479
7	80	50.6	19.5	8.7	5.0	2.6	1.9	1.5	0.6386
7	85	52.9	21.3	9.1	5.5	2.8	2.0	1.5	0.6789
7	90	51.2	20.0	8.6	4.7	2.5	1.9	1.4	0.6417

Subgrade

SEC	STA	DF1 mils	DF2 mils	DF3 mils	DF4 mils	DF5 mils	DF6 mils	DF7 mils	BASIN in^2
8	10	49.1	22.0	9.9	5.8	3.0	2.0	1.6	0.6743
8	15	46.0	16.9	8.1	4.8	2.4	1.7	1.3	0.5782
8	20	45.9	20.3	8.5	4.4	2.2	1.6	1.3	0.6014
8	25	38.7	17.4	7.7	4.3	2.7	1.8	1.4	0.5363
8	30	52.5	22.6	8.0	4.3	2.2	1.7	1.3	0.6588
8	35	57.4	24.2	10.6	5.0	2.2	1.7	1.2	0.7254
8	40	54.6	19.8	8.1	4.3	2.2	1.6	1.2	0.6464
8	45	47.6	16.4	7.8	4.4	2.4	1.9	1.4	0.5797
8	50	50.3	17.7	8.3	5.2	3.1	2.0	1.6	0.6293
8	55	55.3	20.6	9.1	5.1	3.0	2.0	1.7	0.6867
8	60	43.4	18.6	7.6	4.4	2.6	1.9	1.5	0.5766
8	65	56.6	24.3	9.7	5.2	2.6	1.9	1.5	0.7254
8	70	59.8	23.9	9.2	5.0	2.6	2.0	1.3	0.7378
8	75	53.5	19.4	7.2	3.4	2.0	1.7	1.3	0.6216
8	80	87.3	44.7	10.1	5.0	2.2	1.6	1.0	1.0835
8	85	97.8	36.5	13.5	5.4	2.4	1.8	1.3	1.1052
8	90	50.9	18.8	6.6	4.0	2.6	1.9	1.4	0.6138

Subgrade

SEC	STA	DF1 mils	DF2 mils	DF3 mils	DF4 mils	DF5 mils	DF6 mils	DF7 mils	BASIN in^2
9	10	55.2	18.9	7.6	4.3	2.3	1.8	1.4	0.6417
9	15	44.5	15.9	7.9	4.6	2.5	1.9	1.5	0.5611
9	20	42.4	18.0	8.6	5.4	2.8	2.0	1.5	0.5828
9	25	38.0	13.9	6.4	3.8	2.1	1.6	1.3	0.4790
9	30	34.4	15.1	6.3	3.5	2.0	1.5	1.2	0.4604
9	35	45.0	19.1	7.0	3.7	2.0	1.6	1.2	0.5689
9	40	43.5	14.5	7.3	4.7	2.6	1.9	1.5	0.5410
9	45	41.0	18.7	8.6	4.4	2.2	1.7	1.5	0.5627
9	50	47.6	19.9	7.5	4.0	2.2	1.7	1.3	0.5999
9	55	47.8	18.6	6.6	3.6	2.0	1.6	1.2	0.5766
9	60	61.5	16.9	6.6	3.5	1.9	1.6	1.2	0.6402
9	65	60.3	20.5	7.2	3.8	2.0	1.6	1.2	0.6743
9	70	47.5	18.8	7.3	3.9	2.0	1.5	1.3	0.5844
9	75	48.2	16.3	5.0	3.2	2.2	1.7	1.3	0.5503
9	80	49.8	18.0	7.9	5.0	2.9	2.1	1.6	0.6216
9	85	49.2	19.3	8.0	4.4	2.3	1.8	1.3	0.6138
9	90	52.1	18.0	8.2	4.6	2.4	1.8	1.3	0.6247

Subgrade

SEC	STA	DF1 mils	DF2 mils	DF3 mils	DF4 mils	DF5 mils	DF6 mils	DF7 mils	BASIN in^2
10	10	62.0	19.1	8.5	5.5	2.7	2.0	1.5	0.7099
10	15	51.7	13.7	6.7	4.4	2.5	1.9	1.4	0.5735
10	20	52.7	19.3	7.8	4.4	2.2	1.6	1.2	0.6293
10	25	55.2	17.4	5.6	3.5	1.9	1.5	1.1	0.5999
10	30	55.2	18.3	7.2	4.1	2.3	1.8	1.3	0.6324
10	35	49.0	16.2	6.9	4.4	2.3	1.7	1.2	0.5766
10	40	52.4	14.5	5.8	3.7	2.2	1.6	1.2	0.5673
10	45	50.9	17.2	7.2	4.3	2.3	1.7	1.3	0.5968
10	50	46.0	14.8	5.6	3.5	2.0	1.6	1.5	0.5270
10	55	52.9	17.6	7.0	4.3	2.5	1.8	1.3	0.6154
10	60	47.2	15.4	7.4	4.7	2.4	1.8	1.4	0.5689
10	65	46.7	14.1	7.1	4.1	2.4	1.8	1.3	0.5456
10	70	64.6	14.4	5.9	4.0	2.4	1.9	1.4	0.6479
10	75	47.7	11.7	5.5	3.5	2.1	1.6	1.2	0.5084
10	80	51.2	13.4	5.7	3.4	1.8	1.5	1.3	0.5394
10	85	57.0	16.7	7.2	4.1	2.0	1.5	1.2	0.6216
10	90	53.3	16.3	7.2	4.1	2.1	1.6	1.2	0.5983

APPENDIX C: BACK-CALCULATED SUBGRADE MODULUS.

TEST SECTION	ELASTIC MODULUS (psi)		
	LOCATION	FWD	CLEGG
1	10	13757	13158
1	15	15742	14660
1	20	15388	17909
1	25	15905	13899
1	30	18648	9137
1	35	17916	13158
1	40	21179	13158
1	45	16931	16244
1	50	13113	12437
1	55	12813	11736
1	60	15105	21483
1	65	13696	15442
1	70	10976	15442
1	75	10323	18772
1	80	11135	15442
1	85	9063	15442
1	90	9017	14660
2	10	17509	15442
2	15	19081	15442
2	20	16050	16244
2	25	20141	5848
2	30	19534	15442
2	35	14433	17066
2	40	12277	13158
2	50	10918	9137
2	55	10908	11736
2	60	7906	9137
2	65	9117	10396
2	70	13575	15442
2	75	13383	11056
2	80	10562	17066
2	85	7158	13158
2	90	6666	4914
3	10	14604	14660
3	15	14727	14660
3	20	13696	13158

TEST SECTION	ELASTIC MODULUS (psi)		
	LOCATION	FWD	CLEGG
3	25	17143	13158
3	30	19350	16244
3	35	15884	12437
3	40	14727	11736
3	45	15014	13158
3	50	13071	20559
3	60	6810	14660
3	65	10021	16244
3	70	8811	13899
3	75	8125	4914
3	80	9303	9137
3	85	7298	7401
3	90	6641	2284
4	10	12463	9756
4	15	11135	3665
4	20	11818	7401
4	25	9965	6345
4	35	13268	6345
4	40	10062	7401
4	45	9124	6345
4	50	10608	7959
4	55	11145	15442
4	60	8425	6345
4	65	9908	7959
4	70	10455	4061
5	10	10908	7959
5	15	12228	11736
5	20	11105	7959
5	25	16283	13899
5	30	13442	4914
5	35	11750	5370
5	40	9338	5370
5	45	9869	6863
5	50	9540	6863
5	55	9829	6345
5	60	7738	4061

TEST SECTION	ELASTIC MODULUS (psi)		
	LOCATION	FWD	CLEGG
5	65	8638	8538
5	70	7234	4477
5	75	9395	4914
5	80	5157	4061
5	85	6840	2599
5	90	7289	4061
6	10	9585	4477
6	15	10455	6345
6	20	9338	4061
6	25	9268	5370
6	30	11955	14660
6	35	12629	8538
6	40	10937	9137
6	45	11477	9756
6	50	10718	9137
6	55	8830	5370
6	60	9438	9137
6	65	11841	9137
6	70	9607	10396
6	75	9212	5370
6	80	7642	2284
6	85	8014	5848
6	90	10341	4061
7	10	11773	12437
7	15	12476	13158
7	20	14535	13158
7	25	13225	15442
7	30	11165	5848
7	35	10204	13158
7	40	11639	9756
7	45	10976	9756
7	50	10195	9137
7	55	10784	9137
7	60	11762	11736
7	65	11065	13158
7	70	11329	9756

TEST SECTION	ELASTIC MODULUS (psi)		
	LOCATION	FWD	CLEGG
7	75	8779	10396
7	80	9585	6863
7	85	9171	9137
7	90	9482	7959
8	10	9877	2934
8	15	10544	7959
8	20	10571	12437
8	25	12539	16244
8	30	9240	4477
8	35	8454	4477
8	40	8880	2284
8	45	10204	5848
8	50	9645	6863
8	55	8773	5370
8	60	11175	5848
8	65	8578	7959
8	70	8115	6863
8	75	9070	4061
8	80	5557	3665
8	85	4960	4914
8	90	9526	4477
9	10	8792	6345
9	15	10898	9137
9	20	11434	13158
9	25	12760	13158
9	30	14119	11736
9	35	10775	4061
9	40	11165	5370
9	45	11829	15442
9	50	10204	4477
9	55	10145	7959
9	60	7896	4914
9	65	8046	4477
9	70	10212	6345
9	75	10062	6863
9	80	9752	8538

TEST SECTION	ELASTIC MODULUS (psi)		
	LOCATION	FWD	CLEGG
9	85	9869	5370
9	90	9310	5848
10	10	7821	3289
10	15	9395	3289
10	20	9212	6345
10	25	8798	4061
10	30	8798	6863
10	35	9900	4061
10	40	9254	2934
10	45	9540	4061
10	50	10544	5370
10	55	9178	3665
10	60	10280	4477
10	65	10402	4914
10	70	7516	2934
10	75	10170	3665
10	80	9482	4914
10	85	8507	3665
10	90	9110	4914

APPENDIX D: FIELD CBR DATA FROM CLEGG HAMMER AND IN-SITU CBR TESTING.

Test Section	Location	Subgrade Clegg (CIV)	Base Clegg (CIV)	Subgrade Clegg (CBR)	Base Clegg (CBR)	Subgrade CBR (CBR)	Base CBR (CBR)	Subgrade DCP (CBR)	Base DCP (CBR)
1	10	36	16	91	18			38	20
1	15	38	25	101	44				17
1	20	42	8	123	4	25		33	17
1	25	37	37	96	96		7		15
1	30	30		63				32	17
1	35	36		91					12
1	40	36		91				19	22
1	45	40		112					19
1	50	35		86		39	9	29	14
1	55	34		81					13
1	60	46		148				23	15
1	65	39		106					17
1	70	39		106				24	14
1	75	43		129			8		16
1	80	39		106		32		26	16
1	85	39		106					11
1	90	38		101				32	14
2	10	39		106				28	31
2	15	39		106					31
2	20	40		112		20		25	30
2	25	24		40			24		33
2	30	39		106				36	29
2	35	41		118					26
2	40	36		91				22	28
2	45	35		86					26
2	50	30		63		21	39	24	27
2	55	34		81					25
2	60	30		63				16	25
2	65	32		72					31
2	70	39		106				27	26
2	75	33		76			32		28
2	80	41		118		27		24	29
2	85	36		91					34
2	90	22		34				21	39

Test Section	Location	Subgrade Clegg (CIV)	Base Clegg (CIV)	Subgrade Clegg (CBR)	Base Clegg (CBR)	Subgrade CBR (CBR)	Base CBR (CBR)	Subgrade DCP (CBR)	Base DCP (CBR)
3	10	38	24	101	40			19	
3	15	38	28	101	55				
3	20	36	29	91	59			42	
3	25	36	27	91	51		19		
3	30	40	29	112	59			29	
3	35	35	29	86	59				
3	40	34	27	81	51			32	
3	45	36	26	91	47				
3	50	45	26	142	47	29	28	38	
3	55	56	24	220	40				
3	60	38	25	101	44			19	
3	65	40	20	112	28				
3	70	37	27	96	51			31	
3	75	22	19	34	25		18		
3	80	30	25	63	44	44		11	
3	85	27	26	51	47				
3	90	15	24	16	40			10	
4	10	31	29	67	59			25	
4	15	19	32	25	72				
4	20	27	32	51	72	32		30	
4	25	25	32	44	72		33		
4	30	3	30	1	63			28	
4	35	25	28	44	55				
4	40	27	30	51	63			32	
4	45	25	34	44	81				
4	50	28	33	55	76	32	40	33	
4	55	39	37	106	96				
4	60	25	61	44	260			12	
4	65	28	64	55	287				
4	70	20	30	28	63			13	
4	75	75	34	394	81		25		
4	80	80	29	448	59	29		11	
4	85	85	31	506	67				
4	90	90	25	567	44			13	

Test Section	Location	Subgrade Clegg (CIV)	Base Clegg (CIV)	Subgrade Clegg (CBR)	Base Clegg (CBR)	Subgrade CBR (CBR)	Base CBR (CBR)	Subgrade DCP (CBR)	Base DCP (CBR)
5	10	28	29	55	59			15	55
5	15	34	35	81	86				57
5	20	28	86	55	518	25		21	61
5	25	37	25	96	44		12		59
5	30	22	37	34	96			23	54
5	35	23	40	37	112				60
5	40	23	43	37	129			21	54
5	45	26	41	47	118				56
5	50	26	46	47	148	17	36	22	54
5	55	25	47	44	155				65
5	60	20	57	28	227			12	66
5	65	29	52	59	189				56
5	70	21	41	31	118			23	60
5	75	22	40	34	112		23		51
5	80	20	35	28	86	14		11	64
5	85	16	43	18	129				62
5	90	20	39	28	106			8	89
6	10	21	54	31	204			17	92
6	15	25	53	44	197				85
6	20	20	50	28	175	17		15	73
6	25	23	34	37	81		40		81
6	30	38	55	101	212			18	77
6	35	29	47	59	155				63
6	40	30	42	63	123			21	63
6	45	31	47	67	155				66
6	50	30	52	63	189	28	50	19	74
6	55	23	54	37	204				74
6	60	30	50	63	175			17	62
6	65	30	45	63	142				65
6	70	32	41	72	118			22	69
6	75	23	37	37	96		46		81
6	80	15	51	16	182	8		10	61
6	85	24	53	40	197				119
6	90	20	44	28	136			13	88

Test Section	Location	Subgrade Clegg (CIV)	Base Clegg (CIV)	Subgrade Clegg (CBR)	Base Clegg (CBR)	Subgrade CBR (CBR)	Base CBR (CBR)	Subgrade DCP (CBR)	Base DCP (CBR)
7	10	35	76	86	404			13	146
7	15	36	52	91	189				78
7	20	36	49	91	168	38		29	71
7	25	39	68	106	324		25		76
7	30	24	56	40	220			14	80
7	35	36	66	91	305				85
7	40	31	73	67	373			19	77
7	45	31	66	67	305				64
7	50	30	68	63	324	34	32	17	
7	55	30	69	63	333				
7	60	34	68	81	324			18	
7	65	36	94	91	619				
7	70	31	67	67	314			11	
7	75	32	73	72	373		53		
7	80	26	77	47	415	36		16	
7	85	30	72	63	363				
7	90	28	70	55	343			11	
8	10	17	38	20	101			17	119
8	15	28	42	55	123				111
8	20	35	42	86	123	17		14	92
8	25	40	52	112	189		49		83
8	30	21	47	31	155			26	71
8	35	21	42	31	123				67
8	40	15	37	16	96			11	75
8	45	24	35	40	86				115
8	50	26	41	47	118	23	36	26	67
8	55	23	56	37	220				86
8	60	24	32	40	72			12	60
8	65	28	41	55	118				91
8	70	26	45	47	142			15	81
8	75	20	38	28	101		41		67
8	80	19		25		16		10	60
8	85	22		34					73
8	90	21		31				9	44

Test Section	Location	Subgrade Clegg (CIV)	Base Clegg (CIV)	Subgrade Clegg (CBR)	Base Clegg (CBR)	Subgrade CBR (CBR)	Base CBR (CBR)	Subgrade DCP (CBR)	Base DCP (CBR)
9	10	25		44				13	
9	15	30		63					
9	20	36		91		44		15	
9	25	36		91					
9	30	34		81				22	
9	35	20		28					
9	40	23		37				17	
9	45	39		106					
9	50	21		31		37		16	
9	55	28		55					
9	60	22		34				10	
9	65	21		31					
9	70	25		44				12	
9	75	26		47					
9	80	29		59		28		14	
9	85	23		37					
9	90	24		40				18	
10	10	18		23				16	
10	15	18		23					
10	20	25		44		19		9	
10	25	20		28			49		
10	30	26		47				16	
10	35	20		28					
10	40	17		20				17	
10	45	20		28					
10	50	23		37		23	28	12	145
10	55	19		25					
10	60	21		31				18	
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13. ABSTRACT (*Maximum 200 words*)
In 1992, the New Hampshire Department of Transportation (NHDOT) experimented with the use of reclaimed asphalt concrete as a base course material, identified by NHDOT as reclaimed stabilized base (RSB). The RSB and a control test section were placed on Interstate 93 between exits 18 and 19. The RSB test section was designed to the same structural number (SN) as the control. To evaluate the structural capacity of these test sections, the U.S. Army Cold Regions Research and Engineering Laboratory (CRREL) conducted deflection tests using a Dynatest 8000 falling weight deflectometer (FWD). Preliminary analysis of the results by NHDOT personnel showed higher deflections in the reclaimed asphalt concrete test sections. The explanation was that the layer coefficient used for the RSB layer in the design was probably incorrect. A total of 10 test sections constituting the base course materials used by NHDOT were built near Bow, New Hampshire. CRREL evaluated and estimated the layer coefficients of the base course materials. The test program was developed to characterize the material in more than one way. Tests were conducted with the heavy weight deflectometer (HWD), dynamic cone penetrometer (DCP) and the Clegg hammer. In-situ California bearing ratio (CBR) tests were also conducted. The deflections from the HWD were used with the WESDEF back-calculation program to determine the layer moduli. The moduli were than used with the AASHTO Design Guide to calculate the layer coefficients. The layer coefficients were also determined with the method proposed by Rohde. The CBR values from the Clegg hammer, in-situ CBR and DCP tests were also used in the relationships in the HDM model to determine the layer coefficients.

14. SUBJECT TERMS
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